U.S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

Public Roads

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U. S. DEPARTMENT OF AGRICULTURE

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FOUR YEARS OF ROAD BUILDING UNDER THE FEDERAL-AID ACT.

By THOS. H. MACDONALD, Chief of Bureau of Public Roads.

PENETRATION MACADAM ROAD, FEDERAL-AID PROJECT NO. 67, BERKELEY COUNTY, WEST VIRGINIA.

ON July 11, 1916, President Wilson signed the measure generally known as the Federal-aid road act, under which the Government has since cooperated with the States in the construction of highways. For nearly a century previous the Government had taken no part whatever in the improvement of the roads of the country. By signing the road measure, therefore, the President gave his approval to a radical departure from existing governmental policy. The new policy did not contemplate the construction of Federal roads as a separate system apart from the systems of State and local roads; on the contrary, it aimed to stimulate the construction of the roads of the country through the agency of State highway departments.

After four years of operation under this plan it is appropriate that we stop for a moment to review the methods which have been adopted by the Government and the States in putting into effect the purposes of the act; and to examine the progress that has been made toward the goal that was set.

OUTSTANDING RESULTS OF FEDERAL AID.

In spite of the delays incident to the prosecution of the greatest of wars; in the face of strikes which have crippled the transportation systems of the country and reduced the output of necessary materials of construction to a degree unprecedented in the history of the Nation, the program of cooperative highway construction, laid down in 1916, has been adhered to and the results which have been obtained thus far stamp the plan as an unqualified success.

One of the earliest and most far-reaching results, directly attributable to the act, was the creation of adequate State highway departments in 17 States, which previously had either no State department at all or which had departments insufficiently equipped to perform necessary functions. In one year, after the passage of the act, more constructive State highway legislation was placed upon the statute books than had ever before been enacted in the history of the country in a similar period, and a condition was brought about which otherwise would not have been reached in 5 or 10 years. This legislative activity was a direct consequence of the conditions imposed upon the States by the Federal aid act.

The insistence of the Government upon the construction of Federal-aid roads under the supervision of engineers of the State departments has resulted in the placing of more and more of the road work of the country under skilled supervision. In 1915, the year before the Federal-aid act was passed, only 30 per cent of the expenditure for roads and bridges built in the United States was expended under the supervision of State highway departments. This year the State departments will exercise control over fully 80 per cent

of the large sums that will be spent for road construction.

In 1915 the total expenditure for roads and bridges by all the States and local governments was only $267,000,000. This year it is estimated that the funds available for main road construction are approximately $633,000,000. The willingness of the public to appropriate these greatly increased sums is largely traceable to the confidence which has been inspired by the creation and strengthening of the State highway departments, the immediate cause of which was the Federal-aid act.

The manner in which the large sums of Federal money have been apportioned among the States is an accomplishment which has seldom been referred to, but it should be, nevertheless, a source of gratification to all the agencies which have cooperated in the work. In all, the sum of $266,750,000 has been divided among 48 States to the entire satisfaction of all interests involved, and without the slightest suggestion of impropriety or the least suspicion of favoritism.

CONCRETE ROAD IN RAPIDES PARISH, LOUISIANA, PROJECT NO. 13.

The actual road operations under the act thus far involve the approval of projects the aggregate length of which would span the distance between New York and San Francisco nine times, and the estimated cost of which is greater than that of the Panama Canal. Under construction at the present time there are 15,944 miles of road, equivalent in length to five roads from the Atlantic to the Pacific; and the equivalent of 5,500 miles of road has been completed.

Sixty per cent of the total allotment of Federal funds which has been approved to date will be spent for roads of such durable types as bituminous concrete, Portland cement concrete and vitrified brick; and these roads when they are built will increase by 7,600 miles the total of 14,400 miles of roads of this class which existed in the whole United States the year before the enactment of the Federal aid law.

In their contract with the Government the States have given assurance that every mile of road constructed will be properly maintained; in fact, the requirements of the Federal aid act have been directly responsible for the enactment of laws in a number of States providing specifically for the maintenance of all roads constructed, whether with or without Federal aid.

IMPORTANT PROVISIONS OF THE ACT.

The sum of $75,000,000 which was appropriated by the original act for rural post roads was made available in installments at the rate of $5,000,000 for the fiscal year which ended June 30, 1917, $10,000,000 for the fiscal year 1918, $15,000,000 for 1919, $20,000,000 for 1920, and $25,000,000 for the fiscal year which ends June 30, 1921.

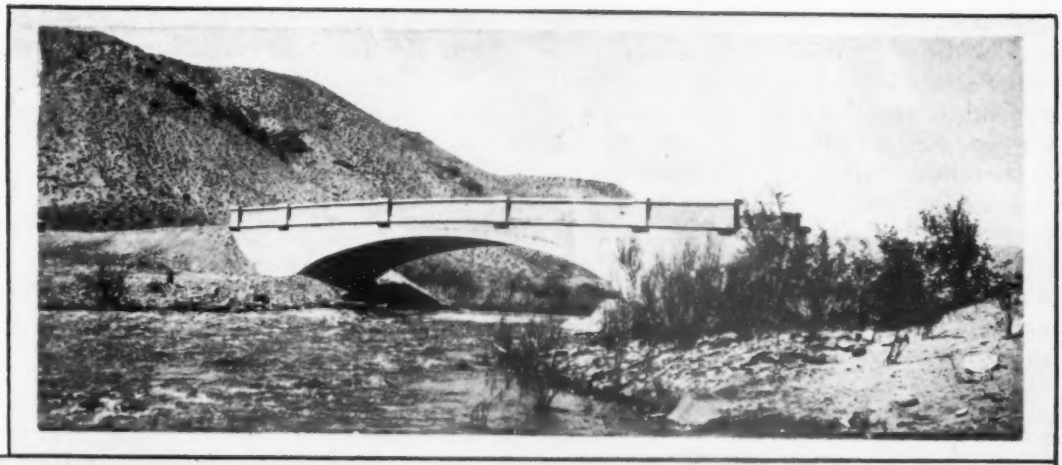
The $10,000,000 for forest roads was made available at the rate of $1,000,000 per year beginning July 1, 1916.

The act provided that a sum not to exceed 3 per cent of the post-road appropriation may be used by the Secretary of Agriculture for administering its provisions.

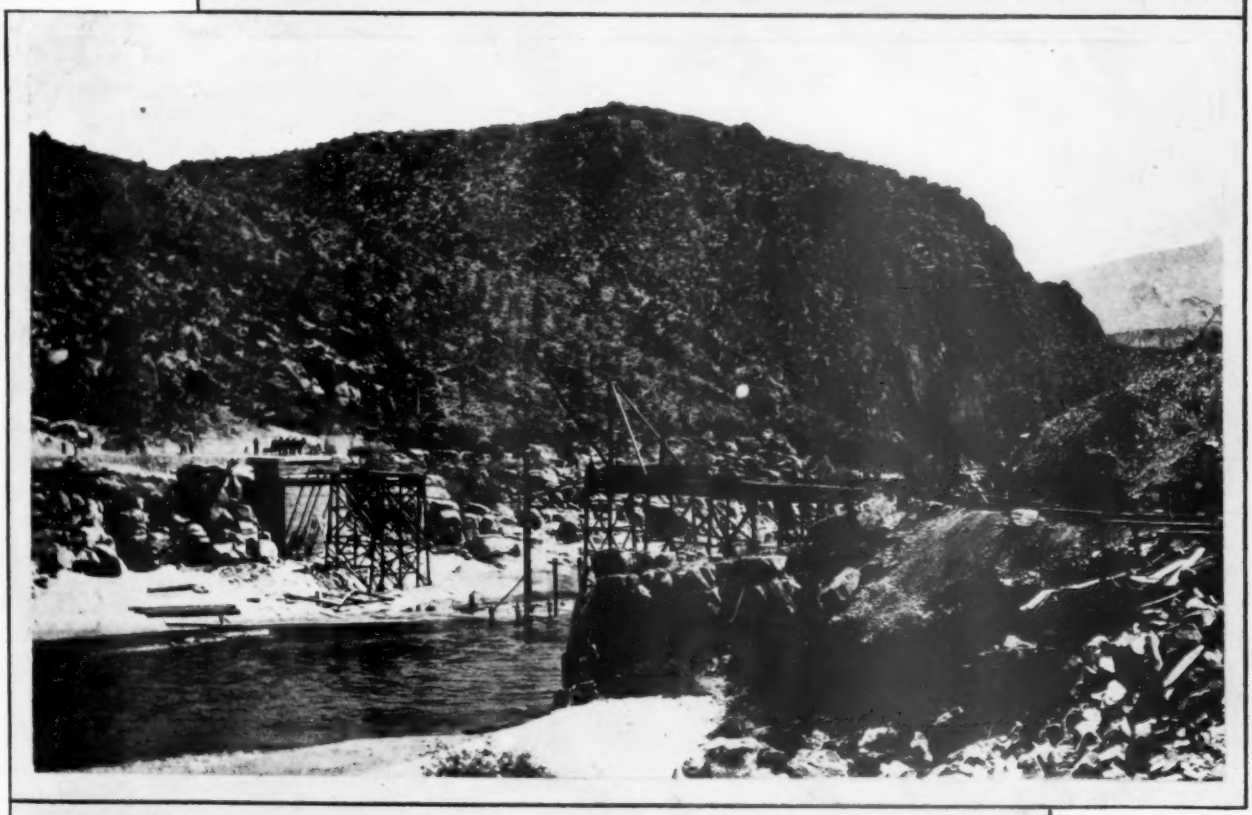
The apportionment of the post-road appropriations of the States, after deducting the administrative fund, is based upon area, population, and mileage of rural delivery and star routes in each State, each of these factors having a weight of one-third.

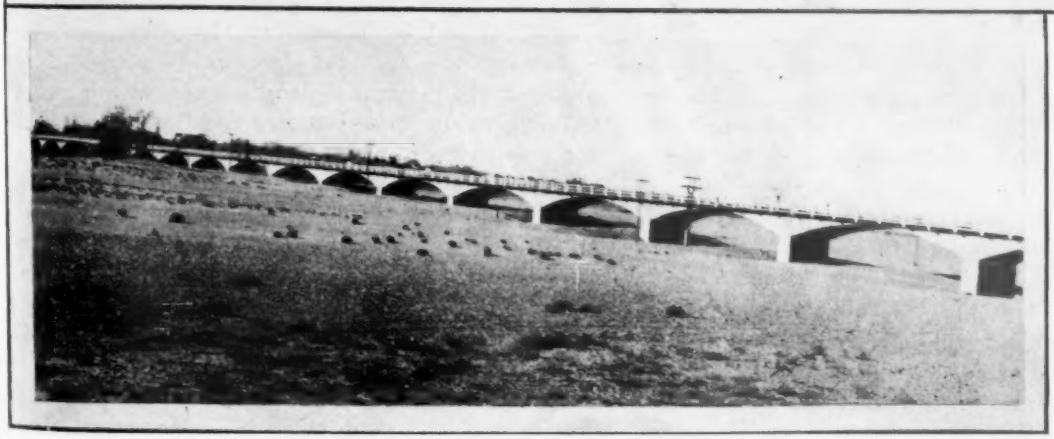
Federal funds may be expended only for construction, must not exceed 50 per cent of the value of the roads, and in the original act it was provided that the expenditure of Government funds could be, in no case, in excess of $10,000 per mile exclusive of bridges of more than 20 feet clear span. This provision was amended by a subsequent act, and the amount of Federal funds which could be expended was increased to $20,000 per mile.

The act laid down three requirements with which the States were asked to comply before they could receive allotments of Federal aid; first, that the State legislatures should assent to the provisions of the act, or that the governors of those States in which the legislative bodies were not in session should assent pending



THE BULKHEAD OF A BRIDGE OVER THE WEST WALKER RIVER, NEVADA, ON FEDERAL-AID PROJECT NO. 8 B.





VIEW OF EAST SIDE OF CAUSEWAY OVER MAIN OVERFLOW CHANNEL OF SACRAMENTO RIVER, ON CALIFORNIA PROJECT NO. 42. THE CAUSEWAY CONSISTS OF 30 65-FOOT SPANS.

BRIDGE BUILDING ON FEDERAL-AID PROJECTS IN THE WEST. THE CENTER VIEW IS OF SALT RIVER BRIDGE, ON PROJECT NO. 14, ARIZONA, IN COURSE OF ERECTION.

the convening of the legislatures; second, that each State should have a State highway department, and that these departments should have direct supervision over the construction on which Federal funds were to be expended; and third, that the Federal aid should be met by an appropriation of at least an equal amount of State funds. A number of States in turn require certain conditions to be met by their counties, such as the raising of county funds, the establishment of guarantees as to maintenance, and the taking of certain administrative steps contemplated by State highway laws. But the Secretary of Agriculture deals only with the State highway department, and thus the State in meeting Federal requirements, acts for the counties whenever their interests are involved.

ARIZONA PROJECT NO. 16. THIS ROAD WILL REDUCE THE DISTANCE BETWEEN PHOENIX AND GLOBE BY 30 MILES, AND FURNISH COMMUNICATION FOR MANY MINING CENTERS.

An immense amount of preliminary work was necessary before the terms of the act itself could be put into operation. First, the Secretary of Agriculture was required to apportion the Federal funds for the first fiscal year to all the States, and in doing this it was necessary that he ascertain from the Postmaster General the "corrected" mileage of rural delivery and star routes, as these formed one of the factors of apportionment.

The act next required the establishment of rules and regulations, and, in their preparation, it was necessary that the views of the several State highway departments should be given careful consideration. The act was approved July 11, 1916, and 10 days later, July 21, 1916, the certificate of apportionment was issued. The rules and regulations, prepared after a conference with the State highway officials, were issued September 1, 1916. After that it was necessary to ascertain which of the States were equipped with highway departments within the meaning of the act, and to await the assent of the State legislatures to the provisions of the act, or of the governors pending the convening of the legislatures in those States in which the legislative bodies were not in session, so that it was 1917 before actual construction work could be undertaken under the terms of the act.

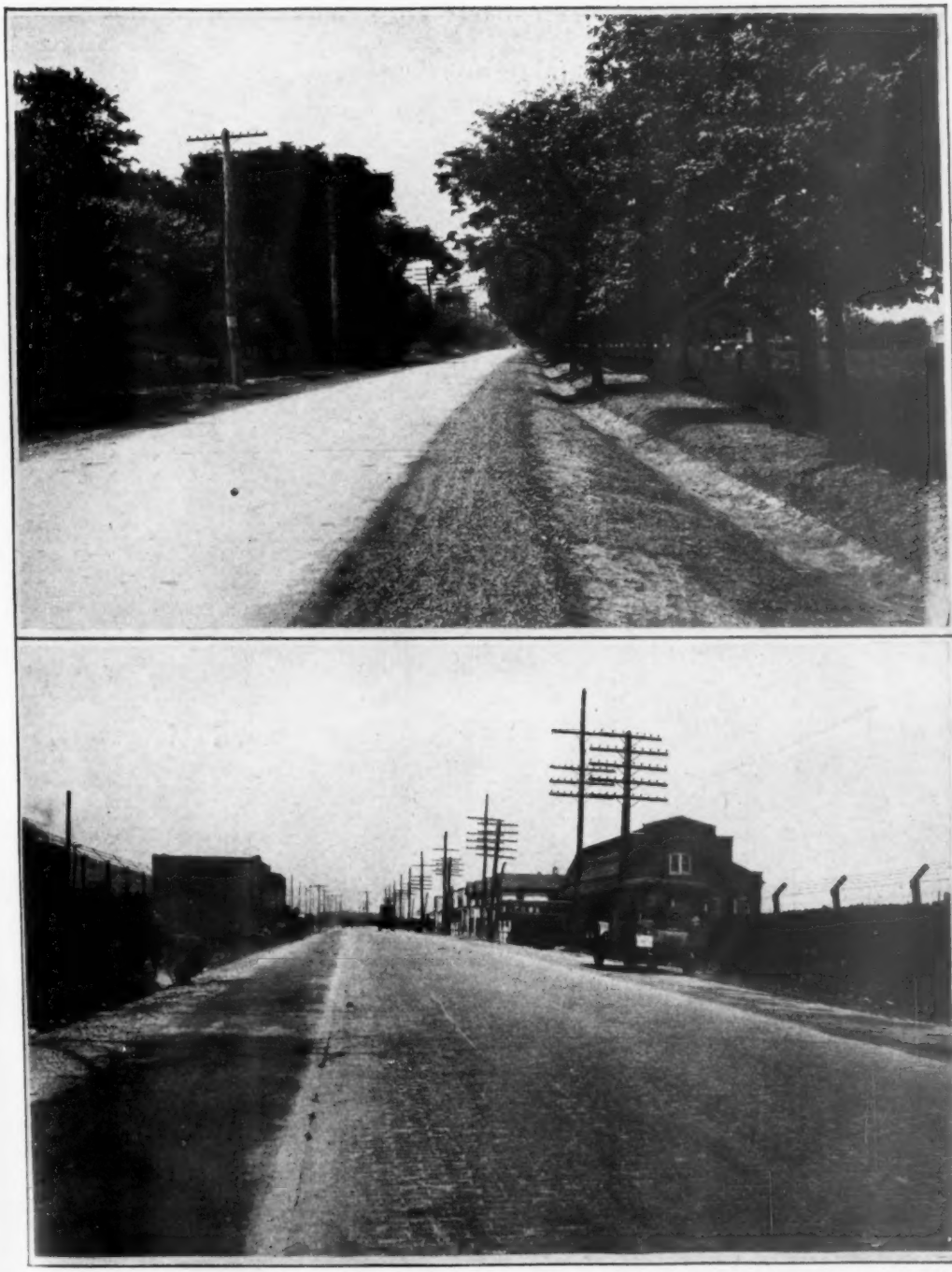
At the outset the States were required to settle upon a definite system of roads in the construction of which they would ask for Federal aid. These systems were selected and maps of them were submitted to the Bureau of Public Roads. Except in about 5 per cent of the projects where the desirability of revisions in these systems has since been made evident, the apportionments of aid to the States have been expended upon parts of these systems. These systems involve about 214,000 miles of road, or only about 8 per cent of the total of 2½ million miles of road in the United States.

This work had hardly begun when war with Germany was declared on April 6, 1917, and from that time until the signing of the armistice, 19 months later, the energies of the Nation were directed to the winning of the war. Other interests were subordinated to the one great aim; and Federal aid road construction was curtailed, wherever possible, to release vitally necessary men and materials for the more important purposes of war.

PROVISIONS OF THE 1919 LAW.

Something over three months after the signing of the armistice, on February 28, 1919, the President, in signing the Post Office appropriation bill for 1920 approved amendments to the original Federal aid act, which provided that the term "rural post roads" as used in that act was to be construed to mean "any public road a major portion of which is now used, or can be used, or forms a connecting link, not to exceed 10 miles in length of any road or roads now or hereafter used for the transportation of the United States mails * * *," and further increased the limitation of $10,000 per mile to $20,000 per mile, as stated above.

Prior to the enactment of these amendments no project could be approved by the Secretary of Agriculture unless it could be ascertained either that the



TOP, NEW JERSEY PROJECT NO. 14, CONCRETE ROAD FROM KINGSTON TO NEW BRUNSWICK. BOTTOM, DELAWARE PROJECT NO. 1, WILMINGTON TO PENNSYLVANIA LINE.

mails were actually carried on the road comprised in the project, or that they would be carried on it within a reasonable time after its completion. A large number of projects had been submitted by the States which the Secretary of Agriculture could not approve because of doubt as to their post road status. The passage of the amendment with its broad construction of the term "rural post roads" permitted the Secretary to approve these projects, all of which were for important roads, and cleared the way for a far more logical selection of the roads to be improved.

The amendment also made it possible for the States to devise more compact State systems on which to apply Federal aid without the danger of having parts of the system ineligible under the original definition of post roads.

The Post Office appropriation bill of February 28, 1919, carried an additional appropriation of $200,000,000 for the construction of Federal aid roads and $9,000,000 additional for the construction and maintenance of roads and trails in the national forests. The new Federal aid appropriation was made available in installments of $50,000,000 immediately, $75,000,000 for the fiscal year ending June 30, 1920, and $75,000,000 for the fiscal year ending June 30, 1921, while the forest road appropriation was made available in three equal installments of $3,000,000 each, available immediately, and for the fiscal years 1920 and 1921, respectively.

The total appropriations made by the acts of 1916 and 1919 for Federal aid and forest roads, and the installments of each by years and the allotments of Federal funds to the several States, by years, are shown in the following table:

APPROPRIATIONS FOR FEDERAL AID AND FOREST ROAD CONSTRUCTION.

Fiscal year.	By act of July 11, 1916.		By act of Feb. 28, 1919.		Total Federal aid.	Total forest.
	Federal aid.	Forest.	Federal aid.	Forest.		
1917	$5,000,000	$1,000,000			$5,000,000	$1,000,000
1918	10,000,000	1,000,000			10,000,000	1,000,000
1919	15,000,000	1,000,000	$50,000,000	$3,000,000	65,000,000	4,000,000
1920	20,000,000	1,000,000	75,000,000	3,000,000	95,000,000	4,000,000
1921	25,000,000	1,000,000	75,000,000	3,000,000	100,000,000	4,000,000
1922		1,000,000				1,000,000
1923		1,000,000				1,000,000
1924		1,000,000				1,000,000
1925		1,000,000				1,000,000
1926		1,000,000				1,000,000
Total	75,000,000	10,000,000	200,000,000	9,000,000	275,000,000	19,000,000

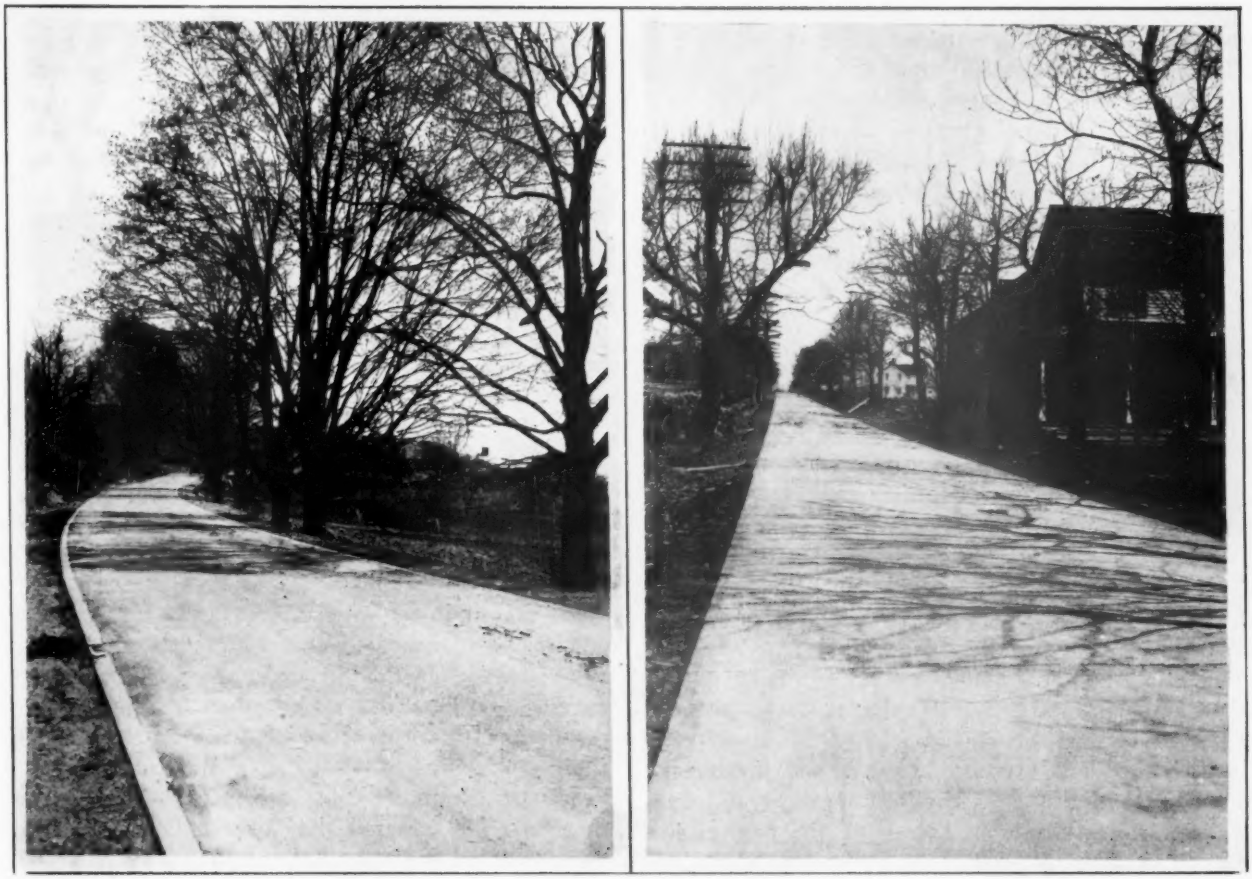
ALLOTMENTS OF FEDERAL AID TO STATES BY YEARS.

State.	Under act of 1916—fiscal year.					Under act of 1919—fiscal year.		
	1917	1918	1919	1920	1921	1919	1920	1921
Alabama	$104,148.90	$208,297.80	$313,456.47	$420,105.64	$526,220.88	$1,050,264.10	$1,575,396.16	$1,578,662.63
Arizona	68,513.52	137,027.04	205,540.58	274,017.43	343,411.04	586,043.58	1,027,565.38	1,030,233.12
Arkansas	82,689.10	165,378.20	250,018.47	336,091.81	421,294.52	840,229.52	1,260,344.28	1,263,883.57
California	151,063.92	302,127.84	456,167.23	609,699.32	763,668.88	1,524,248.30	2,286,372.45	2,291,006.63
Colorado	83,690.14	167,380.28	257,278.92	347,028.36	438,939.79	867,570.91	1,301,356.36	1,316,819.38
Connecticut	31,090.44	62,180.88	92,216.45	122,825.86	153,337.36	307,064.66	460,596.98	460,012.07
Delaware	8,184.37	16,368.74	24,411.99	32,553.78	40,668.70	81,384.46	122,076.68	122,006.11
Florida	55,976.27	111,952.54	170,723.88	229,518.88	286,861.98	573,797.20	860,695.79	860,585.94
Georgia	134,329.48	268,658.96	403,909.45	538,417.90	674,287.74	1,346,044.75	2,019,067.12	2,022,863.22
Idaho	60,463.50	120,927.00	182,471.55	244,203.71	306,512.48	610,509.27	915,763.90	919,537.45
Illinois	220,926.23	441,852.46	658,323.48	874,220.26	1,091,266.98	2,185,550.65	3,278,325.98	3,273,800.93
Indiana	135,747.62	271,495.24	406,230.18	539,967.76	671,763.32	1,349,919.42	2,024,879.12	2,015,289.95
Iowa	146,175.60	292,351.20	434,653.61	577,218.48	720,332.18	1,443,046.20	2,164,569.31	2,160,996.56
Kansas	143,207.40	286,414.80	429,131.88	574,525.57	717,811.16	1,436,313.92	2,154,470.88	2,153,433.46
Kentucky	97,471.91	194,943.82	292,984.62	390,746.07	487,938.86	976,865.18	1,465,297.76	1,463,816.57
Louisiana	67,474.66	134,949.32	203,755.29	272,291.61	340,557.78	680,729.02	1,021,093.54	1,021,673.35
Maine	48,541.50	96,903.00	144,807.42	192,492.62	240,057.54	481,231.55	721,847.32	720,172.62
Maryland	44,047.22	88,094.44	130,871.43	173,894.81	216,749.65	434,737.02	652,105.54	650,248.96
Massachusetts	73,850.95	147,701.90	221,261.85	294,753.32	368,197.21	736,883.30	1,105,324.94	1,104,591.62
Michigan	145,783.72	291,567.44	435,356.37	578,885.52	722,916.99	1,447,213.81	2,170,820.72	2,168,750.98
Minnesota	142,394.06	284,788.12	425,865.40	568,309.81	710,522.33	1,420,774.51	2,131,161.78	2,131,567.00
Mississippi	88,905.84	177,811.68	268,751.60	359,795.31	451,889.29	899,488.28	1,349,232.41	1,355,667.88
Missouri	169,720.41	339,440.82	508,603.98	678,125.64	846,974.90	1,695,314.10	2,542,971.16	2,540,924.70
Montana	98,287.19	196,574.38	298,520.89	396,786.86	501,747.53	999,467.14	1,499,200.72	1,505,242.60
Nebraska	106,770.81	213,541.62	319,445.25	426,656.83	533,435.50	1,066,642.07	1,599,963.10	1,600,306.48
Nevada	64,398.30	128,796.60	193,229.82	257,173.38	319,086.11	642,933.46	964,400.19	957,258.32
New Hampshire	20,996.62	41,993.24	62,610.11	83,124.15	103,709.73	207,810.38	311,715.56	311,129.20
New Jersey	59,212.68	118,425.36	177,357.22	237,620.32	296,889.11	594,050.80	891,076.19	890,667.34
New Mexico	78,737.81	157,475.62	238,634.55	319,514.31	399,616.96	798,785.79	1,198,178.68	1,198,850.89
New York	250,720.27	501,440.54	749,674.20	995,182.56	1,242,973.28	2,487,956.40	3,731,934.59	3,728,919.83
North Carolina	114,381.92	228,763.84	342,556.47	455,990.99	569,763.45	1,139,977.46	1,709,966.20	1,709,280.35
North Dakota	76,143.06	152,286.12	229,585.91	307,344.11	384,056.95	768,360.28	1,152,540.42	1,152,170.85
Ohio	186,905.42	373,810.84	558,043.42	741,784.99	926,561.70	1,854,462.49	2,781,693.74	2,779,685.11
Oklahoma	115,139.00	230,278.00	346,489.34	461,222.20	575,619.58	1,153,055.49	1,729,583.24	1,726,858.75
Oregon	78,687.37	157,374.74	236,332.74	314,983.64	394,038.01	787,459.10	1,181,188.64	1,182,114.02
Pennsylvania	230,644.17	461,288.34	690,145.78	918,430.34	1,147,986.51	2,296,075.84	3,444,113.77	3,443,959.54
Rhode Island	11,665.71	23,331.42	34,972.38	46,612.38	58,314.22	116,530.95	174,796.42	174,942.65
South Carolina	71,807.64	143,615.28	215,014.08	286,918.82	359,004.76	717,297.06	1,075,945.58	1,077,014.28
South Dakota	80,946.02	161,892.04	243,175.61	324,288.27	403,944.86	810,720.66	1,216,081.00	1,211,834.58
Tennessee	114,153.48	228,306.96	340,663.51	452,841.40	565,478.48	1,132,103.49	1,698,155.24	1,696,435.42
Texas	291,927.81	583,855.62	876,986.70	1,170,487.75	1,465,399.62	2,926,219.37	4,389,329.06	4,396,198.84
Utah	56,950.15	113,900.30	170,763.17	227,036.84	282,393.91	567,592.10	851,388.16	847,181.75
Vermont	22,844.47	45,688.94	68,128.92	90,395.08	112,519.27	225,987.69	338,981.54	337,557.82
Virginia	99,660.71	199,321.42	298,120.77	396,821.18	494,418.46	992,052.95	1,488,079.42	1,483,255.37
Washington	71,884.28	143,768.56	216,530.19	288,946.90	361,156.95	722,367.24	1,083,550.87	1,083,470.84
West Virginia	53,270.46	106,540.92	159,713.89	212,803.64	265,038.19	532,009.11	798,013.66	795,114.58
Wisconsin	128,361.07	256,722.14	382,707.20	509,178.61	636,236.34	1,272,946.52	1,909,419.78	1,908,709.01
Wyoming	61,196.82	122,393.64	183,805.78	245,164.98	308,428.96	612,912.44	919,368.67	925,286.88
Total	4,850,000.00	9,700,000.00	14,550,000.00	19,400,000.00	24,250,000.00	48,500,000.00	72,750,000.00	72,750,000.00

ORGANIZATION AND PROCEDURE.

Under the law the Secretary of Agriculture is charged with the administration of the provisions of the Federal aid act. He in turn has delegated the duty of caring for the details of administration to the Bureau of Public Roads. This Bureau was at the time of the passage of the act, and is now, in closer touch with the highway situation and requirements of the country as a whole than any other agency in the United States. Under any other agency Federal operation would have been delayed to permit of the acquisition of necessary preliminary data, which the Bureau of Public Roads had at hand, ready to utilize without delay.

The organization under the Chief of the Bureau of Public Roads which cares for the details of the administration of Federal aid funds consists of a headquarters force headed by the chief engineer in the Washington office, and 13 district engineers in charge of the work in 13 groups of States. The districts vary in size. One embraces only one State, California; others include four or five States; the largest one includes eight States. The district engineers are assisted by a number of engineers who have supervision over sections of the district work. Where the work is sufficiently heavy to warrant it, one or more resident engineers have been placed in a State. In other districts, men are assigned by the district



PENNSYLVANIA FEDERAL-AID PROJECT NO. 29. LEFT, BITUMINOUS MACADAM ROAD, MILFORD TO MATAMORAS, PIKE COUNTY. RIGHT, BITUMINOUS CONCRETE ROAD.

engineer to cover special States, but do not have headquarters in those States. These men are authorized to approve slight changes in plans which become necessary as the work progresses, such as changes in the size of waterways, location of culverts, slight changes in grade and alignment, and even more important changes, providing they do not involve the Government in additional expense. By thus making it possible to effect minor engineering adjustments on the ground, a great deal of time is saved, which would be lost if it were necessary to refer such matters to Washington.

The Federal aid act requires that projects for Federal aid be initiated by the States. As the first step, a statement is forwarded to the district engineer in authority, announcing, in effect, that the State proposes to build a piece of road of a certain type and length in a certain location. This statement is known as the project statement, and it is always accompanied by an approximate estimate of the cost of the proposed construction. The project statement is examined by the district engineer with the purpose of determining whether the project complies with the Federal aid road act. If, in his opinion, it does he forwards the statement to the Washington office with his recommendation. It is there examined by the chief engineer and his assistants, and, if the chief engineer concurs in the recommendation of the district engineer, the project is placed before the Secretary of Agriculture by the chief of the bureau, with the recommendation of the bureau, for his approval.

PROJECTS RAPIDLY CONSIDERED.

Until the Secretary has signified that the United States will cooperate, no further action is taken by the State. If the Secretary approves, the State is so notified, and it then proceeds to prepare detailed plans, specifications and estimates for the work. According to recent reports over half of the projects handled are passed by the district offices in an average of five days. Greater delay at this stage is generally due to the necessity for careful investigation to determine whether the road proposed is of sufficient importance to warrant the expenditure of Federal money upon it. When these doubtful points are cleared up the prompt passage of the project to approval by the Secretary is practically assured, as is shown by the fact that 90 per cent of all projects received at Washington are passed by the bureau in an average of four days.

After the plans and specifications have been prepared by the States they are submitted to the district

engineers, together with a revised estimate of cost based on the carefully computed quantities of work to be done. A representative of the district engineer, either the Federal engineer resident in the State or one especially assigned, makes an inspection of the site of the proposed work, and on this inspection the district engineer bases his recommendation for approval or disapproval of the plans. Very frequently the Federal engineer does not wait until the plans are completed, but goes over the road to be built with the State engineer, pencil profile in hand, and he is often able in this way to suggest changes in the plans as contemplated which facilitate their approval when they are completed.

As soon as the plans, specifications, and estimates are recommended for approval by the district engineer the State may advertise for bids and let the contract. There may be minor adjustments and changes to be made in the plans before they are finally approved by the Secretary, but generally speaking the States do not wait for all these matters to be cleared up before they initiate work on the project. The records of the Bureau of Public Roads show that the plans, specifications, and estimates for over half of the projects are passed through the district offices in an average of five and one-half days and about 90 per cent receive the approval of the chief engineer in three and one-half days. Delays at this stage of the project are generally due to differences of judgment which are serious enough to be given special consideration.

After the plans, specifications, and estimates have been approved, the cooperation of the Government is practically assured. The signing of the formal project agreement follows in due course, but it is not necessary that the work be delayed pending this formality. The authority granted by the Secretary to proceed with construction before the formal completion of the agreement has practically removed all cause for criticism of the Government on the ground of delay.

To cover the cost of administrative work of the Government, an amount not to exceed 3 per cent of the total appropriation for Federal aid is reserved. As the total cost of Federal aid projects is more than twice the amount of the Federal aid apportionment to them, the administrative allowance is really less than 1½ per cent of the total cost of the roads constructed.

ACTUAL ROAD CONSTRUCTION.

Up to June 30, 1920, 2,985 projects involving a total of 29,319.3 miles of road had been approved by the Secretary of Agriculture. The preliminary estimate of the cost of these projects is $384,916,819.53, of which $163,841,503.93 will be approved as Federal aid. On the same date 2,116 projects representing approximately 15,944 miles had either been completed or were under construction. The estimated total cost of these projects in various stages of construction and completed is $200,000,000, and as they average about 34 per cent completed, the value of the work which had been done up to June 30 is approximately $68,000,000. The projects which have been placed under construction since the signing of the armistice involve an expenditure of approximately $181,150,000; those which had been undertaken prior to that time involved only $18,850,000. This means that the actual construction which has been undertaken in the 19 months since the cessation of hostilities is nearly ten times as great as that which had been initiated in the two years and a quarter prior to that time.

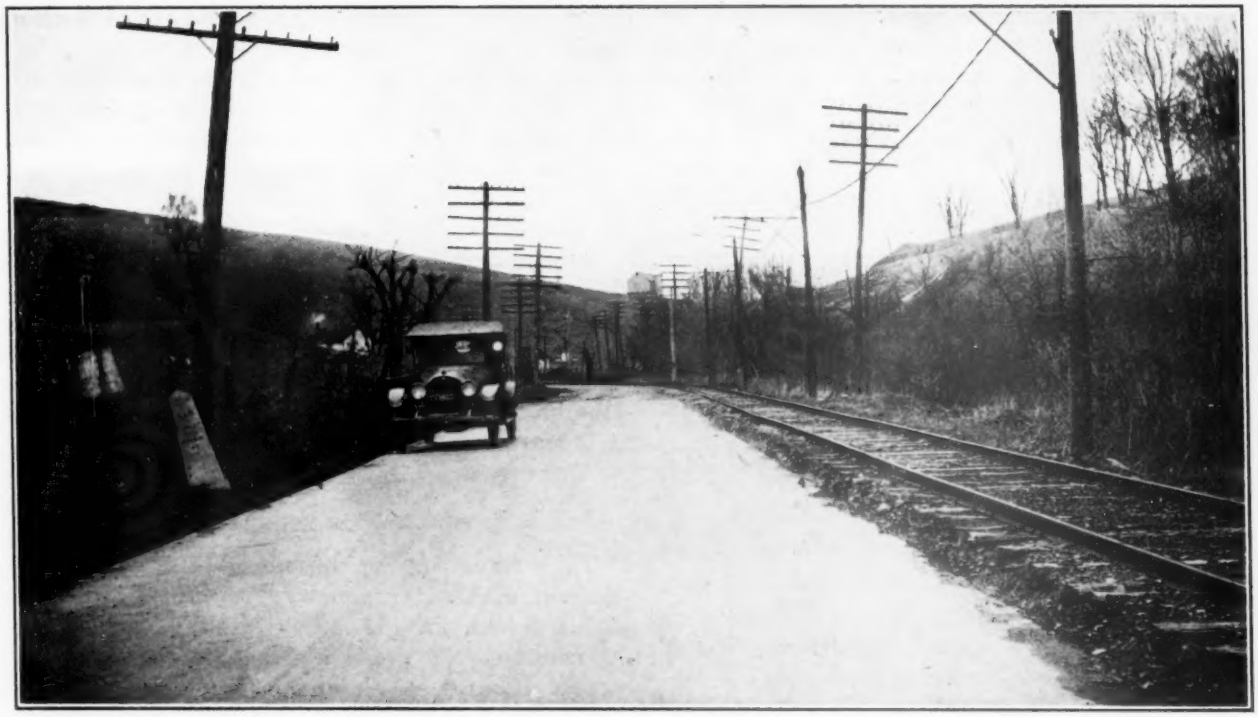
It is interesting to observe that the total cost of Federal aid work approved by the Secretary in the 19 months subsequent to the signing of the armistice and prior to July 1, which is approximately $330,000,000, exceeds by $63,000,000 the cost of all road and bridge work done by States and counties in the United States in the year 1915; and that it is only $40,000,000 less than the total cost of the work done by Americans on the Panama Canal. The performance of this Government in the construction of the canal has been regarded, the world over, as a record-breaking achievement in respect to the dispatch with which it was carried out. The cost of that work was $373,000,000 and it required 10 years to complete, the rate of expenditure being therefore $37,000,000 per year. That record has been equaled by the Federal Government and the States in the construction of Federal-aid roads since the armistice, for in the time since that date—about 19 months—construction work costing $60,000,000 has been completed, a rate of expenditure of $37,000,000 per year. This rate has been attained in the face of the worst economic conditions which have been experienced in a century, and in spite of railroad strikes, inadequate transportation facilities, and shortage of construction materials and labor.

CHARACTER OF FEDERAL-AID ROADS.

The law requires that any construction undertaken under the cooperative plan shall be "substantial in character." Further than this the determination as to the type of the selected roads is left to the joint decision of the Secretary of Agriculture and the State highway departments.

In interpreting the word "substantial" the Secretary has taken cognizance of the fact that an improvement which is substantial for one density and kind of traffic may not be substantial for another. It has been recognized that the types of roads which it is desirable to construct in New York, Massachusetts, and Pennsylvania are not suitable or necessary for Nevada, Idaho, and the Dakotas.

The fact that the former groups of States have a density of population of from 170 to 400 people per



CONCRETE BRIDGE, PROJECT NO. 95, OHIO COUNTY, WEST VIRGINIA. VIEW FROM END OF PROJECT NO. 46 AND BEGINNING OF NO. 95, LOOKING EAST. THE TROLLEY TRACK IS TO BE LOWERED TO THE GRADE OF THE ROAD.

square mile, while the latter have from less than 10 to less than 1, is sufficient to indicate that the road type requirements of the two groups are far from identical. Such a conclusion is reinforced by an examination of the number of automobiles and motor trucks owned and operated in the several States in relation to the mileage of their roads. Thus in the States of Alabama, Arkansas, Nevada, South Dakota, and Oklahoma the number of motor vehicles owned and operated is only 1 per mile of road, while in California there are 8 per mile, in Massachusetts there are 13 per mile, in New Jersey 13, and in Rhode Island 21. Recognizing these facts, the decision as to the type of road which the Secretary will approve for a given locality has been based in every case upon the traffic which is using the existing road and which it is estimated will use the improved road.

The natural conditions obtaining in the several sections of this large country are so diverse that an attempt to fit a uniform type of road of uniform construction as to depth of surfacing or width of right of way would result in overimprovement in one section and perhaps in underimprovement in another. By this it is not meant to infer that no effort has been made to effect standardization of practices and methods where standardization is practicable. On the contrary, as early as April 28, 1917, standards governing the form and arrangement of plans, specifications, and estimates for Federal-aid projects were adopted and issued, and all States have since been working in absolute conformity to these standards in submitting Federal-aid projects. Indeed, they are making use of these standards in connection with work in which the Federal Government does not participate.

This is a case in point to illustrate that the Federal-aid plan has resulted in a standardization of procedure. It has done more: the influence of the Bureau of Public Roads has operated powerfully in the standardization of the details of specification and methods used in the construction of the various types of road the country over. The Bureau has been a clearing house for the collection and dissemination of the best ideas of all the State forces, and through its contact with all the States it has been able to raise the standard of construction in many States by directing attention to improved methods in use in other States. But in deciding upon the adequacy of plans proposed for particular Federal-aid projects the determination as to the type of road which will be constructed, as well as to the location, width, and other matters, is based upon an ascertainment of the facts in the particular case, which is as complete as it may be made. Such decisions must be mutually acceptable to the State highway departments, which look to the interests of the States, and to the Secretary of Agriculture, who acts for the Government. The result is that the Secretary has approved roads of all types and widths, from graded earth roads to concrete, brick, or bituminous concrete, narrow as well as wide; but the essential point is that in each case the decision has

been based upon the best engineering judgment of the Federal Government and the several State highway departments, which between them employ the most highly capable highway engineers in the country.

TYPES OF ROADS APPROVED.

Up to June 30 the total cost of all projects approved by the Secretary was $384,916,819.53. For these projects Federal aid to the amount of $163,841,503.93 has been approved, the apportionment to the various types of road being as shown in the following table:

Proportions of Federal aid approved for various types of surface.

	Per cent.		Per cent.
Earth	8	Low types	26
Sand-clay	3		
Gravel	15		
Waterbound macadam	2	Intermediate types	9
Waterbound macadam, mat-top	1		
Bituminous macadam	5		
Miscellaneous intermediate types	1		
Bituminous concrete	6	High types	60
Concrete	41		
Brick	6		
Miscellaneous high types	7		
Miscellaneous types	5		5

If the various types be divided into three classes, according to their relative wearing qualities under heavy traffic, it will be found that only 26 per cent of the Federal aid approved has been allotted to such roads as earth, sand-clay, gravel, and others which may be regarded as low types. About 9 per cent of the Federal money will be spent for such intermediate types as waterbound and bituminous macadam, and 60 per cent of all the Federal aid approved will go for such high types of construction as bituminous concrete, Portland cement concrete, and brick.

The classification of the mileage of roads approved is somewhat different from the apportionment of the funds. Such a classification is shown in the following table:

Classification of mileage approved—by types.

	Per cent.		Per cent.
Earth	25	Low types	66
Sand-clay	11		
Gravel	30		
Waterbound macadam	4	Intermediate types	9
Waterbound macadam, mat-top	2		
Bituminous macadam	3		
Bituminous concrete	4	High types	23
Concrete	17		
Brick	2		
Miscellaneous			2

It will be noted that, in mileage, the low-type roads preponderate, though the amount of Federal aid allotted to their construction is only about one-quarter of the funds alloted for all types. The mileage of roads of intermediate type is only 9 per ent of the total mileage approved, and 23 per cent of the whole mileage is to be improved with the highest classes of construction.

A large part of the mileage of low-type road which has been approved is in projects in sections of the country where the pioneering work required to open up new territory yet remains to be done. Earth, sand-clay, and gravel surfaces have also been approved in many instances for projects which it is intended at a later date to surface with a more durable material. Whatever money is expended upon such projects for grading and drainage, which represent the major work involved in them, is money well spent for permanent improvement. The slight loss which will be sustained from the depreciation of the surface is far less than the loss which would be sustained as a result of the failure of an expensive surface laid on a new fill.

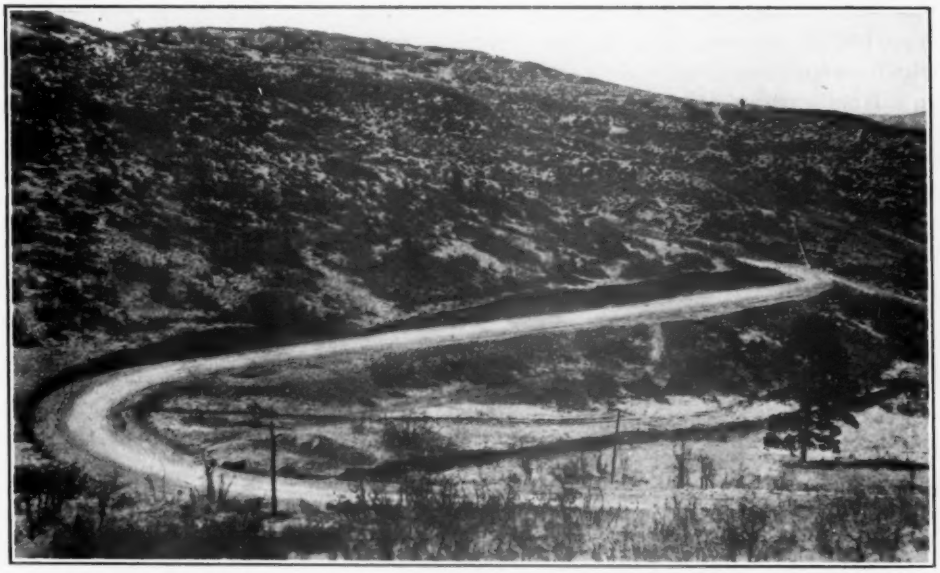
MAINTENANCE OF FEDERAL-AID ROADS.

The Federal-aid act specifically forbids the use of Federal money for maintenance of the roads constructed with Federal aid. The States are expected to maintain the roads constructed; and to enforce proper attention to this important matter, it is provided that future allotments of aid may be withheld from any State which fails to keep its Federal-aid roads in repair. So far it has not been necessary to invoke this provision of the law, and it is unlikely that any State will, in the future, so far neglect its own interest in the roads constructed as to permit the dissipation of its investment in the roads by failure to keep them in repair. The Bureau of Public Roads, however, is making periodic inspections of the roads which have been completed, and will continue to do so, and the States will be expected to comply fully with the terms of their contract with the Government.

FEDERAL SYSTEM OF HIGHWAYS.

In the prosecution of this great work the Federal Government and the several States have acted in the closest cooperation. The dual interest of the Federal and State Governments in the result of the work has been recognized throughout. The roads already constructed and any which may be constructed hereafter will certainly be of greater importance to the States than to the Government at Washington or to the United States as a whole, since 90 per cent of the traffic which will use them will be distinctly local in character. Yet the Federal Government also has an interest in the betterment of the avenues along which this local traffic may flow. A large part of it is the traffic from farms to shipping points and nearby cities and towns; and any improvement which will expedite this traffic will go far to ease the existing critical situation in respect to the supply of agricultural products. This we must regard as most important in these days of high prices of the necessities of life and reduced production of the fruits of the

soil. Whatever works will help in the betterment of the conditions of rural life, the promotion of educational and social opportunities of our rural communities, and the development of the inherent attractions of country life, will increase our agricultural population, and consequently our production of the vitally necessary raw materials.



COLORADO PROJECT NO. 2, WHICH CONNECTS TRINIDAD AND RATON PASS ON THE NEW MEXICO LINE.

The Federal Government, of course, has a direct interest in the development of interstate roads to accommodate that 10 per cent of highway traffic which flows across State lines. Previously this traffic has consisted largely of automobiles driven by tourists in the pursuit of pleasure, and the need for roads to accommodate it has been subordinate to the need for the local roads which actually promote the substantial well-being of the country at large; but lately, with the development of the motor truck, the interstate traffic has taken on a somewhat commercial aspect, and the importance of providing for it has increased. However this traffic can be taken care of by suitable connection of the local roads which are the first necessity—not roads to isolated farms, or country lanes for community travel, but roads radiating from the important country shipping centers which will take up and bring to the major transport lines of the railways the crops of the farmer here, there, and everywhere, which in the aggregate make up America's production.

The same policy may be followed with respect to the military roads which the lessons of recent years have shown to be vitally necessary. There is no support for the assumption that long transcontinental roads will be needed for military defense, a transcontinental road which merely crosses the continent is of little military value. What is needed is a series of roads connecting all important depots, mobilization, and industrial centers, which, as thus connected, may give us a transcontinental route eventually; but the transcontinental feature is of secondary importance. In the main these essential military roads coincide with the roads required for the development of industry and agriculture, though in special cases roads will undoubtedly be required to connect points of strategic importance, which would not otherwise be required.

CALIFORNIA PROJECT NO. 3, A 20-FOOT ROAD WITH 1½ TOPEKA TOP ON A 5-INCH 1:3:6 CONCRETE BASE. UNDER TRAFFIC SINCE 1916.

To assure that all these various uses will be adequately provided for, the Chief of the Bureau of Public Roads has called into consultation the several agencies interested in the development of roads for the several purposes, among them, the War Department, and the several State highway departments. The General Staff of the Army and

the Chief of Engineers already have taken up with the department commanders the question of the roads which are of importance from a military standpoint; an advisory committee of State highway officials is cooperating with the Department of Agriculture to select the most important peace-time roads; and, in conference with these agencies, a systematic program of highway development is being worked out for the whole country, upon the basis of which questions of priority in the construction of roads will hereafter be settled.

ASPHALT FILLER IN GRANITE BLOCK WORK.

A typical granite block pavement has just been completed on a section of Battery Place in lower Manhattan, New York. In 1906 this thoroughfare was paved with wood block, but under a series of repairs the pavement was gradually replaced by granite block. This type of pavement was found necessary because of the weighty wagon and automobile freight traffic on Battery Place between Broadway and the North River piers.

In 1918 the work of putting granite block entirely over Battery Place was completed with the exception of a part of the thoroughfare which had been occupied by a large Red Cross storage shed. In May of this year it was decided to raze this shed and to tear up the old wood block on which it was built. Granite block with asphalt filler was the type selected by the street department to conform with the rest of Battery Place.

The 6-inch concrete base upon which the old wood block had been laid was in fairly good shape. With a little filling in of pot holes and leveling off it furnished a satisfactory support for the new granite block. Over this base was spread a cushion of cement and sand which provided an even bed for the granite blocks. The pavers then proceeded with the laying of the blocks, great care being taken to see that they were firmly set in the cushion of sand, to prevent the crushing of unevenly laid blocks. After tamping the pavement was ready for the application of the asphalt filler.

The asphalt filler was heated in a specially designed kettle constructed after specifications furnished by the contractor. The kettle has a capacity of 300 gallons; is able to cover 500 square yards a day, and is built in such a way that maximum benefit is derived from the heat. In case of necessity the filler could be prepared for application in three hours.

The filler in this particular job was applied in the form of a mastic. Equal quantities of asphalt and sand, heated to approximately the same temperature, were mixed thoroughly immediately before being applied. In order to apply them effectively both asphalt and sand were heated to from 350 to 400 degrees Fahrenheit. After a homogeneous mixture had been formed, it was poured directly over the surface of the blocks and forced into the interstices with a hot-iron squeegee.

In this case only one application of the filler was made, but it is often advisable to make two applications. The filler settles in cooling and sometimes leaves the edges of the block unprotected and at the mercy of heavy traffic. As a final step in the construction, sand was spread over the pavement to absorb the surplus asphalt left on the surface. The consolidation of this surplus asphalt and the sand forms a protective mat which greatly reduces the noise of traffic and tends to lengthen the life of the pavment.

A pavement of this type may be open to traffic immediately upon completion.

IOWA ROADS MARKED.

Iowa counties have very largely decided to put up signs along the primary road system. The week of July 12 has been selected as road-marking week. Iowa's road number system is similar to that in use in several Middle Western States—Wisconsin, Ohio, Minnesota, Illinois, Michigan, and Nebraska. In this system an important main-traveled road between important transportation centers is given a designating number, which is painted on telegraph, telephone, or specially erected poles at every intersection, turn, crossroad between these centers, and also at times at points between crossroads. A traveler has simply to follow the route number leading to his destination.

So far as possible numbers on important interstate routes through Iowa have been given numbers corresponding to the number of the same road in adjoining States. When Iowa started numbering her roads it was found that the Jefferson Highway was No. 1 in Minnesota, and that number was assigned to the highway through Iowa. The River to River road in Illinois was No. 7, and it became No. 7 in Iowa. The Blue Grass trail is No. 8 in both Illinois and Iowa.

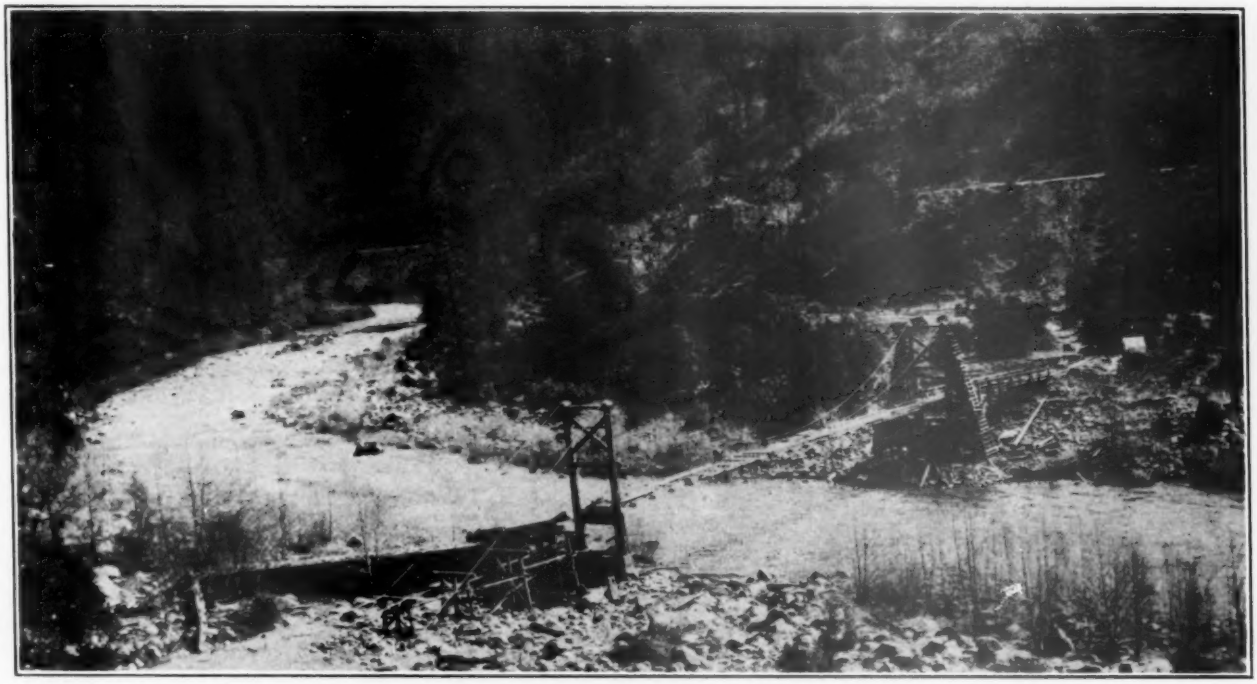
MAINE EXPENDITURES.

Maine in 1919 expended $344,879.58 on State highways, $1,113,998.67 on State-aid highways, and $340,885.74 for bridges, a total of $1,799,763.99 for road construction. For maintenance, $344,879.58 was spent on State highways and $339,091.88 on State-aid highways, a total of $673,971.46.

In the maintenance work 478 patrolmen were employed, 668.60 miles of State highways and 843.72 of improved and 2,772.52 of unimproved State-aid highways were looked after, a total of 4,284.52 miles maintained. In addition, 74.12 miles of State-aid roads were maintained under special arrangements by towns.

FEDERAL ROAD BUILDING IN THE NATIONAL FORESTS OF THE WEST.

By L. I. HEWES, General Inspector, Bureau of Public Roads.



WORKMAN'S BRIDGE ACROSS FEATHER RIVER, PLUMAS NATIONAL FOREST, SHOWING BULKHEAD WHICH PROTECTS NORTH APPROACH DURING HIGH WATER.

WEST of the one hundred and third meridian the people of the United States possess a forest of 154,000,000 acres. This forest lies between the Pacific Ocean and the eastern boundary of Montana, Wyoming, Colorado, and New Mexico. Its definite Federal administration was established by Congress in 1905, and it was subdivided into 6 forest districts and 151 separate national forests.

Within these national forests lie 15,000 miles of State and county highways. The improvement of these roads and the development of additional subsidiary administration and fire protection roads constitutes the national-forest roads project.

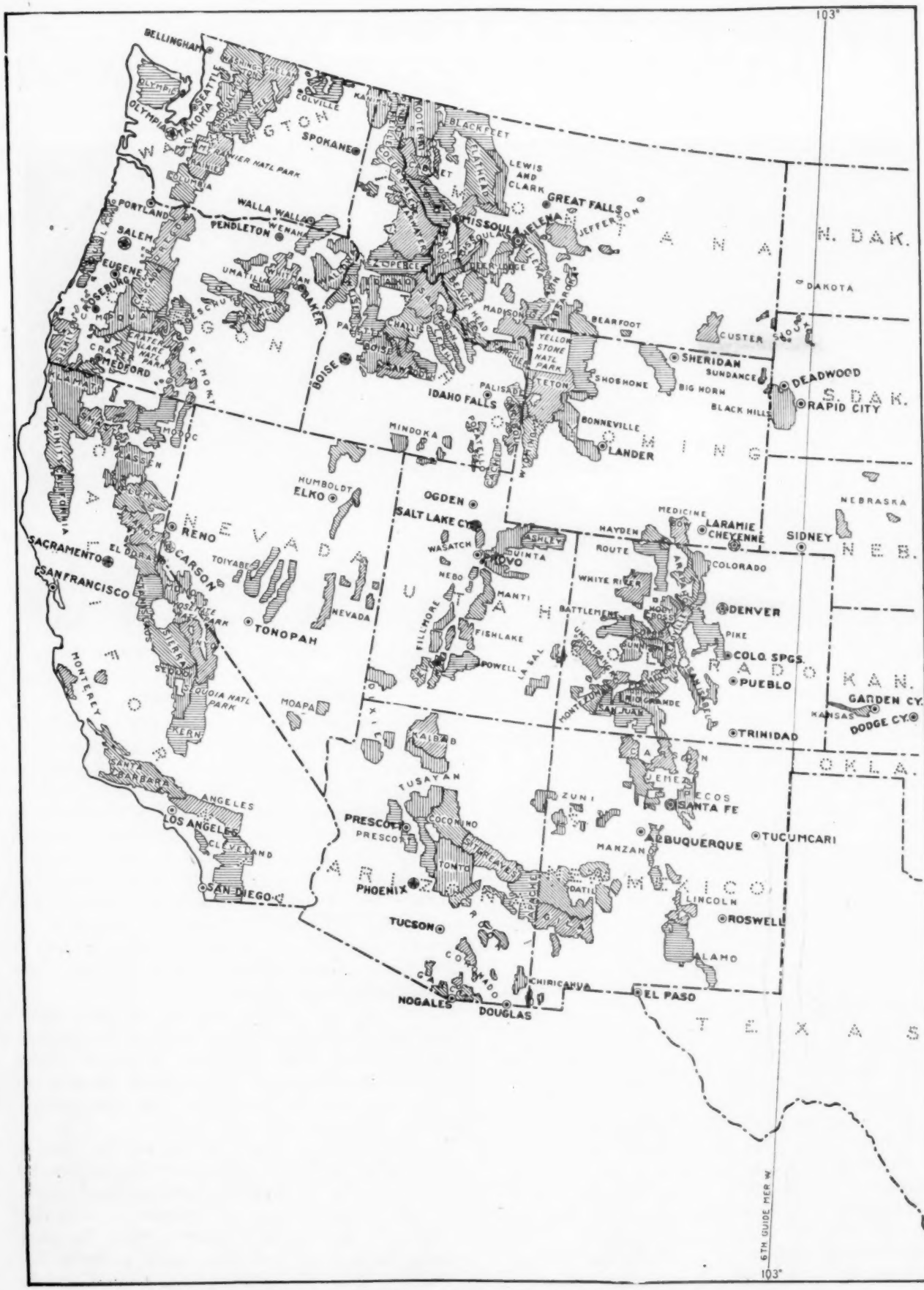
The work of surveying and constructing these highways was begun in 1914. Funds were then very limited and the magnitude of the task was scarcely realized, but the program of survey and construction has now become one of the most extensive in the country. It is directed, cooperatively, by the Forest Service and the Bureau of Public Roads of the Department of Agriculture. The Forest Service classifies the roads within the national forests, sets up a working plan from year to year of the order of improvement of various projects, and enters into agreement with the States and counties to finance the projects. From this point the Bureau of Public Roads takes charge and handles the work of survey and construction.

FINANCING FOREST ROADS.

Federal financing of the national-forest road program has been provided for mainly in three ways. First, in point of time, by the 10 per cent national-forest fund which is made up of 10 per cent of the revenues of the national forests and is applicable to roads and trails within the forests of the State in which the fund originates. This fund in the past eight years has amounted to $2,322,225. It may be used by the Secretary of Agriculture with or without local cooperation. Prior to 1917 most of this money was expended for the construction by the Forest Service of roads of minor standard but vital to the safety and administration of the forests.

Second, the Federal aid road act of 1916 appropriated $1,000,000 annually for 10 years for the construction of the roads and trails within or partly within the national forests with equitable cooperation by the local authorities. This fund has already amounted to $5,000,000.

Third, the emergency appropriation in the amendment to the post-office act of 1919 provided $3,000,000 annually for three years for the construction of roads and trails by the Secretary of Agriculture. The last $3,000,000 becomes available in July, 1920. Roughly speaking, then, there had been made available up to January 1 of the current year approximately



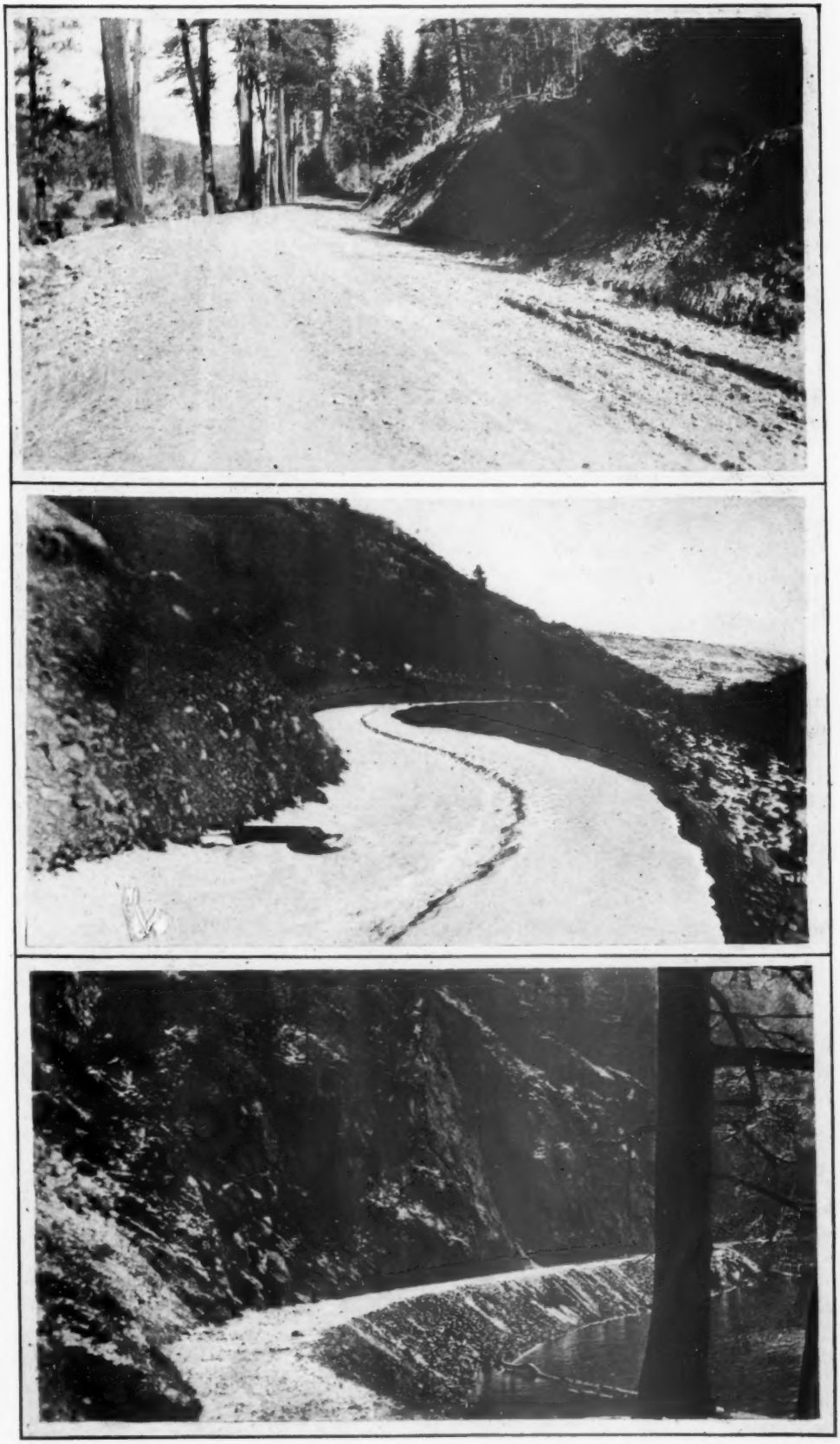
SHADED PORTIONS OF MAP SHOW LOCATIONS OF NATIONAL FORESTS IN THE WEST.

$12,300,000 of Federal funds for the construction of national forest roads. There is at present a total of $6,513,347 worth of construction in progress supervised by the Bureau of Public Roads, and since the passage of the Federal-aid road act 30 projects costing $2,018,703 had been completed. These are major projects only. The construction of minor roads and trails is done entirely by the Forest Service.

AREA AND LOCATION OF THE FORESTS.

The geography of this great forest-road program is indicated by the map of the 11 States on page 16. These States total in area 1,179,095 square miles, which slightly exceeds the combined area of 15 countries of western continental Europe. Over this third of our country are distributed national forests north and south through 17½ degrees of latitude and east and west from the plains to the Pacific. The net forest area is 208,467 square miles, which is over 20,000 square miles greater than all the New England and North Atlantic States.

Looking closer, the map will show that the shaded forest areas coincide with the great mountain ranges. West of Denver are massed the eastern outposts of the Rocky Mountains. Here are forest roads at an elevation of nearly 10,000 feet. From Canada along the Statelines of Montana and Idaho, across the Yellowstone National Park and southward over the flat summit of Sherman



TOP, A GRADED FOREST ROAD IN OCHOCO CANYON, OCHOCO NATIONAL FOREST. CENTER, NEW SNOW ON THE MONARCH PASS ROAD, WHICH CROSSES THE CONTINENTAL DIVIDE IN COLORADO AT A HEIGHT OF 10,000 FEET. BOTTOM, FOREST ROAD ALONG LAKE CRESCENT, OLYMPIC NATIONAL FOREST, WASHINGTON.

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Hill extends the Continental Divide through the center of continuous forests. Down into Utah east of Ogden along the beautiful Wasatch Range the forests continue and then beyond the Grand Canyon at the Kaibab Forest to the Tonto Forest of Arizona, in which lies the Roosevelt Dam, and finally through the Apache Forest to the Mexican line. West of the divide in Oregon and Nevada are detached forest areas stretching southwesterly along secondary ranges. In the north the forests of the Blue Mountains form the southern rim of the Columbia River drainage basin and finally reaching across Oregon they join the Cascade Range at Crater Lake. The splendid Cascade Mountains themselves are clearly marked by areas of forests straight from the Canadian boundary across the States of Washington and Oregon and into California. Here the Sierras continue the forest zone southward past Mount Lassen and the Yosemite and Sequoia Parks to the Mojave Desert. All the western peaks are in this area—Baker, Rainier, St. Helens, Hood, and Shasta.

Beginning again in the north at Puget Sound, the great Olympic Forest occupies most of the Olympic Peninsula and other isolated forest areas follow the Coast Range through Oregon southward across the rugged canyon of the Klamath River. In Southern California near the coast are continuous narrow forests of surprising interest, topping for 500 miles the ranges back of Santa Barbara, Los Angeles, and San Diego.

In the Territory of Alaska are the Tongass and Chugach Forests stretching from the coast inland to the mountain tops. They occupy 20,000,000 acres and have 15,000 miles of coast line.

The rocky structure of these western mountain ranges, coupled with the isolation of the projects, the dense forest cover and the snow in the passes make the construction of roads through the national forests possibly the most interesting and probably the most difficult road building in the United States.

ROADS WITHIN THE FORESTS.

During 1919 the Forest Service made a comprehensive investigation of the total mileage of existing county and State roads lying within the boundaries of the forests. The following table shows the result of this study:

State.	State roads.	County roads.	Cost of grading and drainage of State roads, at $15,000 per mile.	Cost of grading and drainage of county roads, at $7,500 per mile.
	Miles.	*Miles.*		
Idaho	153	402	$2,295,000	$3,015,000
Nevada	44	159	660,000	1,192,500
Utah	228	201	3,420,000	1,507,500
Wyoming	77	26	1,155,000	195,000
Montana	65	1,675	975,000	12,561,500
New Mexico	437	43	6,555,000	322,500
Arizona	300	306	4,500,000	2,295,000
Colorado	997	100	14,955,000	750,000
South Dakota	90	170	1,350,000	1,275,000
California	[1] 45 563	3,685	8,445,000	27,637,500
Oregon	[1] 65 345	[1] 220 1,444	5,175,000	10,730,000
Washington	[1] 27 222	[1] 95	3,330,000	.....
Alaska	[1] 30 140	945	2,100,000	7,087,500
Total	[1] 167 3,661	[1] 315 9,156	54,915,000	68,570,000

[1] Already constructed.

If only the roads of greatest duty are surfaced, the improvement of an adequate system of roads to serve as connecting links of State highway systems and as main county laterals and for fire protection, administration, and the development of the forests, will cost over $150,000,000.

WHY FOREST ROAD WORK IMPORTANT.

The importance of this forest road work may best be realized by a study of some of the salient geographic and topographic features of the forest areas. First, because the national forests lie along the mountain summits they contain roads which must cross the mountain passes on all the trunk highways from the Great Plains to the Pacific and from the north to the south. Except to the westerner and the traveler, the the idea of altitude may not carry great significance. But the effect of altitude may be realized when it is stated that from the Canadian boundary to Helena, Mont., there has never yet been built a road crossing the Rocky Mountains. Automobilists who visit Glacier National Park can not drive from Glacier to Bolton, 30 miles away, until the road partly within the Blackfeet Forest along the southern boundary of the park is completed. There is no road in the State of Washington that can be traveled the entire year across the Cascade Mountains between the Inland-Empire and Puget Sound and western Washington populations. The same is true in Oregon. The only all-the-year passable road from the Columbia basin to the coast is down the gorge of the Columbia River; and at the point where the Cascade Range would cross the river a national forest road has just been constructed on the north bank from Stevenson to White Salmon. There are now in process of construction in the 11 Western States more than 20 projects, all of which run over mountain passes at elevations of from 3,000 to 10,000 feet. These particular roads involve some of the most difficult pieces of construction in the entire western road program, and many are connecting links in State highways. The McKenzie Pass Road across the Cascade Mountains between Eugene and Bend in Oregon runs for 3 miles on a mountain top over a fresh lava flow on which not a single plant grows.

Second, every national park in the western one-third of the continent is practically surrounded by national forests, and motorists can not reach the roads already constructed in the national parks unless the roads through the forests leading to the parks are first constructed.

Glacier National Park in Montana is bordered by the Blackfeet National Forest; the Yellowstone is completely surrounded by six forests, except for a narrow strip along the railroad branch from Livingston. Mount Rainier is completely surrounded; Crater Lake can be approached only through the National forest, although a narrow strip of patented land exists on the southeast; Yosemite is completely surrounded, except for the road to El Porto; and Sequoia lies in the heart of the Sequoia Forest.

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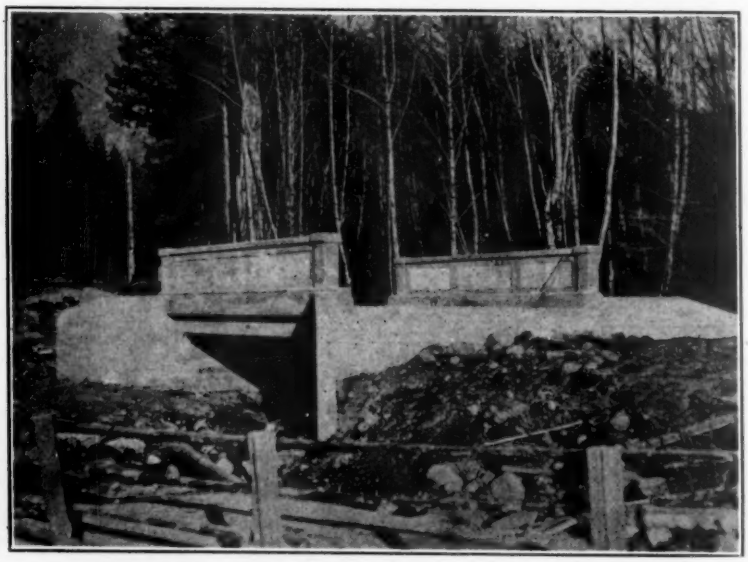
MATCHLESS CRATER LAKE, IN CRATER LAKE NATIONAL FOREST. A FOREST ROAD NOW UNDER CONSTRUCTION WILL REACH THIS LAKE.

Third, in addition to the national parks within the great national forests there lie many natural beauty spots as yet very little known to the public and to which access may be had only by National-forest roads. Such, for example, is the wonderfully beautiful Lake Crescent in the Olympic National Forest. Here, within 9 miles of the Pacific, at an elevation of nearly 500 feet, lies a lake 11 miles long, surrounded by virgin forests, which affords possibly the most splendid trout fishing in the country. Knowing fishermen journey from the ends of the earth to visit this lake in the month of April to catch the extraordinary "Beardslee" and "Crescenti" trout, yet the new forest road which is now under construction as a part of the Olympic Highway will, for the first time, make it accessible to motor traffic from Port Angeles. This road project is in a country where primeval conditions have so long existed that the road blasting has driven the deer to new grounds. In Washington is beautiful Lake Chelan, almost completely surrounded by the Chelan National Forest. The Oregon and Cascade Forests stretch southward from the Columbia River along the mountain summits through a region of lakes and mountain peaks of wonderful beauty. Here lies Clear Lake at the headwaters of the McKenzie River, and world famed Crater Lake far southward, and between them are a dozen snow-capped peaks, such as Jefferson and The Sisters. These lakes have some of the best fishing in America and are inaccessible except to packers and campers. Similar conditions apply to northwestern Montana and central Idaho and to many parts of Colorado and the Southwest; to the forests back of Los Angeles and to the exceptionally interesting California coast country; particularly to the Klamath River in the north, flowing for 60 miles through a forest canyon where the placer diggings of '49 are still visible and at intervals still worked.



A CONCRETE CULVERT ON MOUNT HOOD LOOP, A FOREST ROAD.

NEED FOR FIRE FIGHTING ROADS.

But more important than any of these reasons for the construction of forest roads, is the great need of forest fire-fighting roads. To those who have not seen forest fires, particularly in the Northwest, the colossal loss of timber annually can not be realized. Hundreds of fires occur annually in the group of 150 national forests. The duty of the Forest Service is to extinguish these fires as quickly as possible; the secret of successful fire fighting is to arrive in time, hence the need for roads. In the months of July, August, and September every man in the Forest Service must be ready at all times for immediate service against the fire enemy. Two things are most feared, an excessive number of small fires due to lightning, of which several are sure to get beyond control before they are extinguished, or fires within the heart of the most remote and inaccessible forest areas. Sometimes both these worst conditions occur at once. Many will recall the devastating fires of 1910 which were stopped far up the north fork of the Flathead by a miraculous snow fall on August 27. Similar conditions have since threatened the Northwest, notably in 1917 and 1919. To combat these fires the Forest Service has requested the Bureau of Public Roads to construct such roads as the North Fork Flathead, running 30 miles through the Blackfeet Forest to the Canadian boundary; the Yaak project, 25 miles long from Sylvanite through the Kootenai Forest, terminating also at the Canadian boundary; the Swan River Road, 8 miles long, and the Metaline in Washington, 11 miles long. All of the roads in the forests are fire-fighting roads, but 12-foot light built roads of the Yaak type are specially designed for fire fighting and have already done their bit in preventing the spread of serious fires.

In the area of Idaho north of the Salmon River and between Missoula, Mont., and Lewiston lie the Lolo, Bitterroot, Clearwater, Selway, and Nezperce Forests, with a total area of 6,000,000 acres. Here are probably the greatest bodies of white pine timber in America; and as no roads penetrate the region, the fire hazard is alarming. So, a 100-mile road known as the Lolo Pass National Forest Road along the trail of Lewis and Clark has been begun. This road will join Missoula, Mont., with Lewiston, Idaho, through an uninhabited region that has already been surveyed and abandoned by two railroads. For 12 miles the line follows the Black Canyon of the Locksa River, where provisions for survey parties are "back packed" from the Powell Ranger station, 27 miles west of Lolo Pass. Construction is under way above the town of Kooskia, Idaho, where a 640-foot bridge over the North Fork of the Clearwater has been finished and also 20 miles of road. The road will be narrow at first,

TOP, FIRE SWEPT FOREST. ADEQUATE ROADS WILL DO MUCH TO PREVENT THIS TREMENDOUS WASTE OF TIMBER. LOWER LEFT, A FOREST ROAD CLEARING IN THE QUINAULT NATIONAL FOREST. LOWER RIGHT, CLEARINGS THROUGH FORESTS LIKE THIS OFTEN MUST BE MADE IN BUILDING ROADS.

BURROS BRINGING IN RICH COPPER ORE OVER THE OLD CLIFTON-SPRINGERVILLE TRAIL IN ARIZONA. THE NEW FOREST ROAD BETWEEN THESE TOWNS WILL DEVELOP LARGE COPPER MINES.

but its lines and grades will be determined with a view to eventual widening; and it will serve as the shortest northern interstate road between Montana and the Columbia River, Spokane, Portland, and Seattle.

Many other fire-protection roads have been begun or built since the passage of the Federal-aid road act of 1916. Such are the 30-mile Coram Spotted Bear in Montana, and the North Fork Payette, 20 miles long, in south Idaho. The construction campaign began with an attack on the mountain passes and the impassable sections of interstate highway at most remote points.

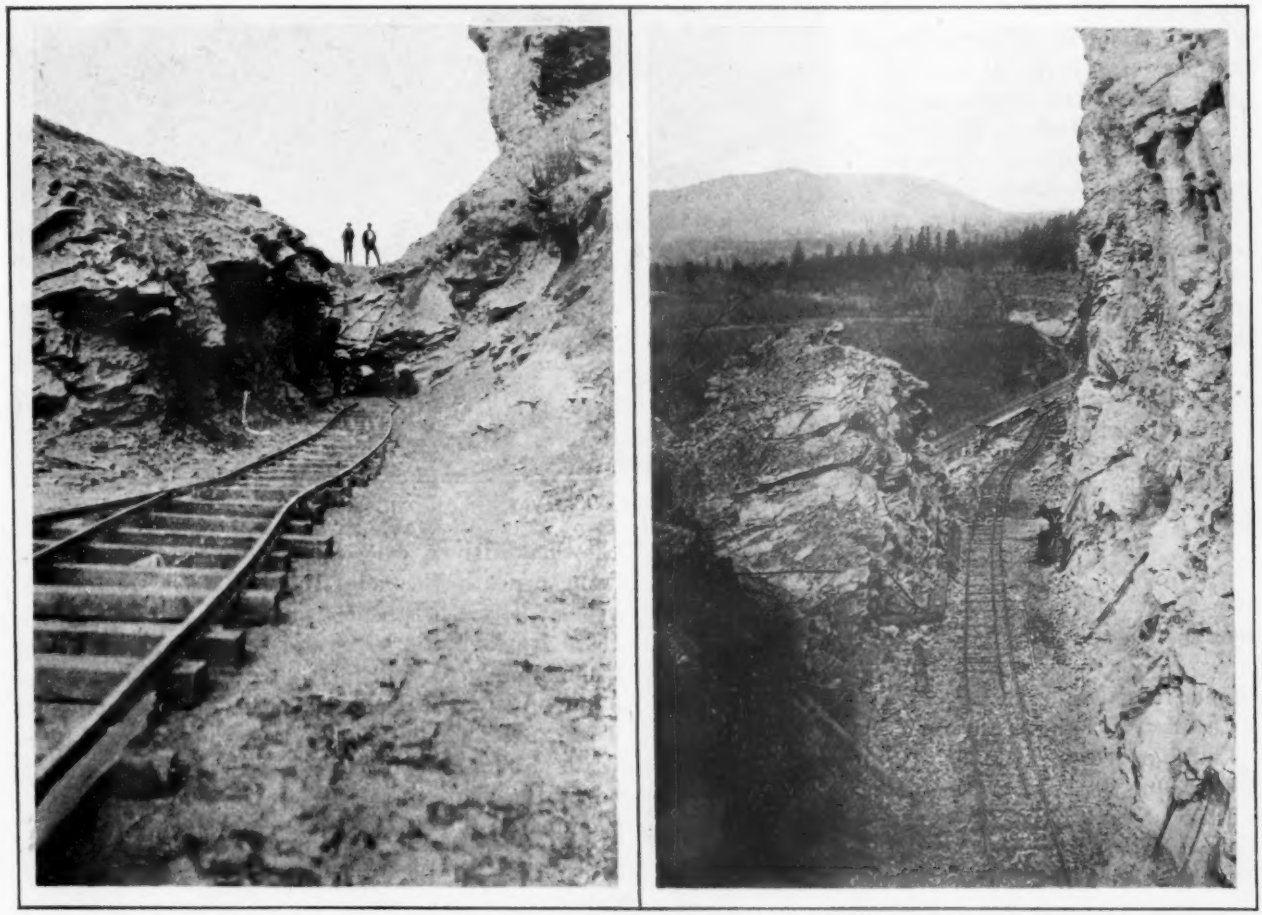
IMPORTANT FOREST ROADS.

The first forest road contract was let in March, 1918, for the Alberton Road in Montana. This is a section of the North Pacific Highway along the Rainbow River west of Missoula, which replaces an almost impassable road on the opposite side, and will connect all western Montana with Wallace, Idaho, and Spokane, Wash. The project is 60 feet above the river and required 6,600 cubic yards of retaining wall in about one-half mile.

On this same interstate highway in Idaho was the notorious "Fourth of July Canyon Road" in the Coeur d'Alene National Forest, where Capt. Mullan passed on July 4, 1865, and inscribed the great fir tree which still stands. Twelve miles of this old trail has just been reconstructed at a cost of about $200,000, and for the first time in the history of north Idaho a good road exists through the difficult region between Spokane and the Coeur d'Alene mines. From the hills on this highway are extraordinarily beautiful views of Lake Coeur d'Alene.

Proceeding farther west on the north bank of the Columbia River Highway in the Columbia National Forest between Cooks and Collins in Washington was 6½ miles of impassable road. This project lay so close above the railroad that material blasted from the basalt ledges had to be very carefully handled to prevent accident. One 600-foot through cut in rock 80 feet above the track practically overhung the rails. It was 30 feet in depth at the maximum point and required 11 months of continuous work to excavate a road 20 feet wide. The finished road is surfaced with gravel and carries a large traffic. Eventually it will be surfaced by the State of Washington with concrete as a part of the interstate highway between Portland and the east via the Northern route.

Passing into Oregon, between Portland and the California line, south of the old stage station at Canyonville, lay possibly the most difficult section of the Pacific Highway. Here a dangerous, crooked, and at times impassable road wound up Cow Creek Canyon and across a low summit to connect with Galesville. Twelve miles of this road has now been thoroughly graded at a cost of approximately $210,000 and will be surfaced by the State of Oregon. Over the canyon on this road will be built the first concrete arch on a national forest road with a 130-foot span. The McKenzie Pass Road between Bend and Eugene in Oregon has been mentioned. Contracts for 30 miles of this 70-mile road have already been let, and the work is well along. A most obstinate section, which will begun shortly, lies on the summit of the Cascade Range at an elevation of 5,000 feet. Here the most recent lava flow in the United States has covered an area many miles in extent. This lava field terminates along a definite line, a part of which is followed by the new forest road and to motorists the appearance of the entire area suggests that the flow might have just occurred. Across this lava flow the construction will



THE COOK-COLLINS, A NATIONAL FOREST ROAD. LEFT, AT WORK ON A ROCK CUT. RIGHT, THE ROAD COMPLETELY ROUGHED OUT THROUGH THIS CUT.

be entirely in rock and one location is no worse than another in point of difficulty.

SPECTACULAR KLAMATH PROJECT.

In California perhaps the most spectacular forest road is the Klamath River project, 42 miles in length, within the Klamath National Forest. The road follows a deep canyon on the hillside, at times passing through stretches of solid granite. It will be 12 feet wide and will open to travel the country between Yreka and the sea for the first time. Along this river a few Indians of the Klamath tribe are living in almost original primitive conditions. A similar project is on the Trinity River in the Trinity National Forest.

In the Southwest are some forest-road projects of great necessity and difficulty and of extraordinary interest. One is the Oracle-Apache Camp project, 30 miles long, in the Coronado Forest in southern Arizona. Work is now in progress at the cost of $11,000 per mile. Part of a cooperative project known as the Clifton-Springerville passes through copper ore so rich that one cut is visibly green. Isolated sections of the project will be in difficult rock and the history of the entire project is a story by itself. In both Arizona and New Mexico are similar projects at high altitudes. In New Mexico is the Glorieta-Panchuela project, a 12.8-mile section of the Santa Fe trail, to cost over $100,000.

To the north in Colorado in the San Juan Forest occurs one of the most spectacular of all of the forest-road projects. This is a 50.5-mile road connecting the towns of Durango and Silverton, passing over two summits at elevations between 9,000 and 10,000 feet. Here no adequate road has ever existed and a new location is required for a large part of the way. From the south pass the road plunges into the Lime Creek Canyon through solid rock for a mile and a half, to rise again to an elevation of 10,000 feet above the mining town of Silverton, from which it descends for the most part on a 5 per cent grade. This road has already been under construction by day-labor forces for two seasons. Thanks to steam shovels and power drills it will probably be completed in 1921. The estimate is approximately $450,000.

In Utah many forest-road projects pass across the mountain ranges running north and south and will afford connections between valleys that never before have been in direct communication. A section in the

Manti Forest between Ephraim and Orangeville rises to an elevation of 9,000 feet, and 4 miles is costing $52,000 for a 12-foot graded section. Similar roads in Utah are the Heber-Fruitland in the Uinta and the Logan-Garden City in the Cache Forest.

In southern Idaho occurs the Ketchum-Clayton project in the Sawtooth National Forest across the Galena Summit on the Sawtooth Highway of Idaho. This road leads into the Stanley Basin country of central Idaho, which is said to be the greatest big-game region existing in the United States. All of these roads are links either in interstate highways or interstate systems.

BOWLDER EXCAVATION ON THE MONARCH PASS ROAD.

ROADS UNDER CONSTRUCTION.

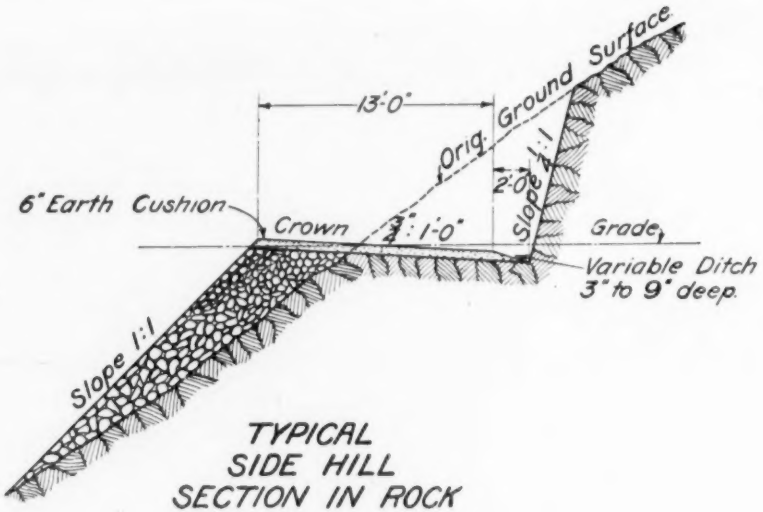
Over 150 miles of National forest roads are also under construction leading into the National parks or forming connecting links between these parks. In Montana four National forest road projects on the direct route from Glacier Park to Yellowstone Park lead for 36 miles over the Little Belt Mountains in Meagher and Cascade Counties, between Great Falls, Helena, and Livingston. Between Glacier Park and the summit of the mountains on the west an 8-mile project in the Lewis and Clark Forest is under construction. Up the West Gallatin River in southern Montana in the Gallatin Forest are 20 miles of road all surveyed and partly constructed at an estimated cost of $84,000. This road will lead into the Yellowstone Park by way of Yellowstone, passing some of the most interesting scenery immediately adjoining the park. On the south in the Targhee Forest are 47 miles leading from Warm River past Henrys Meadows into Yellowstone and forming the last link from the south to our oldest national park. This road will pass close to the Buffalo River and Big Springs, the headwaters of the north fork of the Snake River, where the full-fledged stream springs from beneath the solid rock. In Oregon a 22-mile project between Prospect and the boundary of Crater Lake National Park, in the Crater National Forest, when completed, will for the first time afford tourists opportunity to visit one of the most unique spots in the world. Here, 6,200 feet above the sea, is matchless Crater Lake, unbelievably blue and deep, 2,000 feet below the oval rim of the crater of what must have been one of the greatest volcanoes in the world.

A FOREST ROAD SURVEY CAMP.

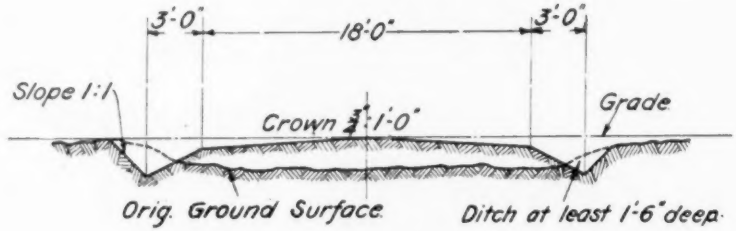
FEATURES OF CONSTRUCTION WORK.

The construction items arising on many of these forest road projects present interesting and unique features. Clearing and grubbing varies from the dense, heavy timber of the Olympic Peninsula in Washington to the grubbing of light sagebrush and cactus on the desert in Arizona. The corresponding prices range from $3,500 per mile to $250. On the Quinault project were trees 8 and 9 feet in diameter. Such clearing becomes a standard logging operation with steam donkey engines. Similar conditions exist in Alaska. Grubbing of the enormous stumps leaves great craters in the grade which often require recross-sectioning to determine changes in quantities.

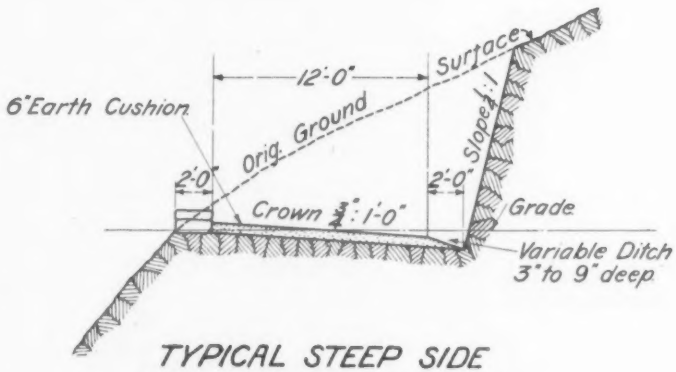
Rock excavation sometimes averages as high as 4,000 yards to the mile on a 16-foot road. It is of all kinds, from bowlder slides, consisting of innumerable masses of rock, which will average several cubic yards in volume, to the basalt cliffs of the Columbia River with vertical hexangular columns from 6 to 60 feet high. Some of the hardest granites occur in Colorado; but even these are not more expensive to work than



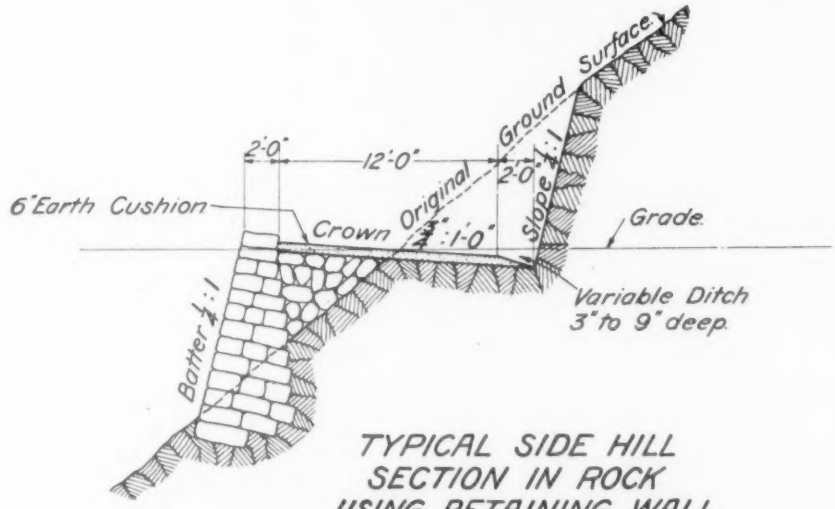
TYPICAL
SIDE HILL
SECTION IN ROCK
(One Way Crown)



TYPICAL
TURNPIKE SECTION
(Two Way Crown)



TYPICAL STEEP SIDE
HILL SECTION IN ROCK
(One Way Crown)



TYPICAL SIDE HILL
SECTION IN ROCK
USING RETAINING WALL
(One Way Crown)

TYPICAL SECTIONS OF FOREST ROADS.

the hard conglomerate or cemented gravel caliche of Arizona and New Mexico, upon which blasting has the minimum effect.

Blasting of rock is taken as a standard item on the western mountains, and the "station gang" of cooperative laborers bidding per 100-foot station or per cubic yard is an institution recognized by all contractors. These men attack the ledge in various ways. Sometimes they use the deep "coyote hole," burrowing 30 feet into the rock with a tunnel large enough to permit a stooping man to enter with a wheelbarrow. Sometimes the hole is smaller, 8 or 10 feet in depth and less than a foot in diameter. Such a hole is known as a "boot jack." One "coyote hole" on the Cooks-Collins Road in Washington brought down 2,000 yards of rock with 1,700 pounds of black powder. On the Canyonville-Galesville job in Oregon batteries of small "coyote holes" 15 feet deep at intervals of 15 feet were shot for distances of two or three stations at a time. The effect was to blow out the base of the side hill prism into canyon and permit the top to drop into its place. The mass was then thoroughly broken and could be handled by a steam shovel.

Along the Klamath River in California section gangs of Greeks are at work using TNT. In the upper reaches of the Clearwater in Idaho on the Kooskia-Lowell project station gangs have worked throughout the past winter. Some of these men at times have reported the extraordinary figure of 20 cubic yards of unclassified material per man per day.

The Bureau of Public Roads specifications classify all excavation as either ledge rock or "common," and these specifications are coming to be adopted by several States. During 1919 approximately 2,000,000 cubic yards of "common" were bid in District 1, at an average price of 78 cents, and 400,000 cubic yards of rock (the Government furnishing TNT) were bid at $1.69.

STATEMENT OF COMPLETED PROJECTS, APRIL 20, 1920.

District.	State.	Project.	Length.	Total cost.	Cost per mile.	Weighted average cost per mile by States.
			Miles.			
1	Oregon	Canyonville-Galesville, section 1	9.9	$210,739	$21,287	
1	do	Canyonville-Galesville, section 2	1.1	54,395	49,450	
1	do	Flora-Enterprise	12.9	88,398	6,852	$13,660
1	do	Middle Elk	2.65	9,142	3,450	
		Total, Oregon	26.55	362,674		
1	Washington	Blewett Pass, section 3 and parts 2, 4, and 5	8.4	183,779	21,878	
1	do	Cooks-Collins	4.7	135,126	28,750	
1	do	Little White Salmon	.8	4,790	5,988	19,768
1	do	Quinault Lake (south)	2.5	39,277	15,711	
1	do	Republic-Wauconda	3.4	28,439	8,364	
		Total, Washington	19.80	391,411		
		Total, District 1	46.35	754,085		
2	California	Workman's Bar Bridge*	341 ft.	6,192		
2	do	Trinity River	4.7	58,193	12,366	
2	do	Klamath, Orleans-Somes Bar Section	7.4	164,750	22,263	
2	do	Laguna Road	14.6	41,820	2,864	9,650, not incl.*
2	do	Hawkins Bar Road and Bridge*	1,486 ft.	17,557		
2	do	Salmon River (Forest Service)	4.0	14,000	3,500	
2	do	Salmon River (B. P. R. prior 1920)	1.0	27,151	27,151	
		Total, District 2	32.17	329,663		
3	Colorado	Nederland-Ward	10.5	54,700	5,210	
3	do	Rabbit Ears	8.94	42,860	4,794	5,092
3	do	Sedalia-Decker Springs	14.82	76,902	5,189	
		Total, District 3	34.26	174,462		
6	Arkansas	Ozark Road	33.85	85,000	2,511	2,511
8	Florida	Crestview-Camp Walton	28.0	94,015	3,358	3,358
11	Montana	Alberton	4.1	63,361	15,454	
11	do	Belt Creek	18.89	145,121	7,682	
11	do	East Fork	5.09	18,926	3,718	6,681
11	do	Sheep Creek, section 1	4.05	25,883	6,416	
11	do	Swan River, Lake Section	8.0	14,702	1,838	
		Total, Montana	40.13	268,093		
11	Idaho	Fourth of July, section 2	3.0	27,372	9,124	
		Total, District 11	43.13	295,465		8,634
12	Idaho	North Fork-Payette	19.9	170,341	8,560	
		Total, Idaho	22.9	197,713		
12	Nevada	Tonopah	13.9	45,000	3,238	3,237
		Total, District 12	33.8	215,341		
13	New Mexico	Highrolls Weed, Sections A and B	7.52	46,286	6,155	
13	do	Tijeras Canyon	4.70	24,386	5,189	5,783
		Total, District 13	12.22	70,672		
		Grand district total	263.61	2,018,703		
		Total average cost per mile (not including projects marked *)				7,581

SURFACING AND DRAINAGE.

Up to the present time none of the forest roads has been surfaced except with fine crushed rock or gravel. The construction therefore consists in the installation of adequate drainage structures and the grading and finishing of the road to the necessary standards demanded by its immediate future duty. Typical cross sections of the forest road are shown in the illustration. Owing to the fact that many of the roads lie in the canyons of mountain streams, side-hill construction prevails. It has generally been found that it is cheaper and better to "bench in" the road rather than to construct retaining walls. At times conditions require the construction of such walls. Dry walls are built with the base six-tenths of the height, and if in excess of 16 feet in height the bottom courses are laid in cement mortar.

Drainage structures of logs are necessarily used in many remote regions. Cedar log culverts and cedar log cribbing are regarded as having great durability. Concrete pipe can be used only within reasonable haul of shipping points, and consequently corrugated metal pipe is found desirable for the longer hauls. With the exception of the more important bridges occurring on projects which are parts of State highways, the superstructures of bridges are of the wood Howe Truss type. On the Quinault River and also on the Salt River in Arizona riveted steel bridges are under construction, and several steel bridges have been built in California. Log crib piers and abutments are extensively used with rock "back fill" and give excellent satisfaction.

CONCRETE FORD AT "MEDDLER'S WASH," SALT RIVER-PLEASANT VALLEY FOREST ROAD, ARIZONA.

CONCRETE FORDS FEATURE.

A feature in the construction of the southwest area is the concrete ford in the arid regions which are subject to cloud-bursts. On the Salt River-Pleasant Valley project in Arizona are a number of these fords built 16 feet wide and nine-tenths of a foot deep. These fords are constructed with "one-man" stones covered with good concrete, and have cost in the neighborhood of $4 per square yard 30 miles above Globe in Arizona.

Interesting studies are underway to determine the relative advantage and economy of the use of steam shovels on national forest road projects as against the handwork of the station gangs. It has already been well established that although a wider road results in most cases with the steam shovel excavation the more workmanlike job follows the station gang method. Contractors using the steam shovel prefer to "borrow and waste" rather than end haul, as it proves economy to them in the end. The station gangs do not remove a surplus yard of material if it is possible to avoid it and leave their banks in excellent shape; also the slower construction of the fills results in a more stable embankment. This is desirable, since it is entirely impracticable to construct fills on heavy mountain excavation by the layer method. Fills are overcast and must be allowed to settle before surface operations can be attempted.

At intervals throughout the West are localities where small, local contract outfits with wheel scrapers and horses are available for grading operations. Contractors are frequently

THIRTY-FOOT BRIDGE ON CRIB ABUTMENTS, TRINITY RIVER ROAD, TRINITY NATIONAL FOREST.

glad to sublet portions of the forest road projects to such outfits.

The table of completed projects gives a comprehensive view of the 263.61 miles completed on April 1, 1920. There are 65 projects with a total of 851.7 miles now under construction in addition to those listed in this table. Surveys have been made for 2,543 miles, and plans have been completed for the greater part of this mileage.

FOREST TRAILS AND MINOR ROADS.

In addition to the road mileage which has been mentioned above, the Forest Service has constructed many miles of forest trails and minor forest roads from the 10 per cent fund and from approximately 25 per cent of the other Federal-aid funds and will continue this work during the present season. Projects now surveyed will require all the available Federal-aid money that has been appropriated except the last three installments of the Federal-aid road act of 1916. The $3,000,000 from this source will give less than $100,000 annually to each of the Western States.

In Alaska approximately $500,000 worth of work is mapped out and partly completed in the Chugach and Tongass Forests. There are 2.4 miles on the Seward Kenai Lake project, 3.2 miles on the Juneau-Eagle River, 6 miles on the Portege Road, and 3.5 miles on the Ketchikan-Wards Cove project. All these projects are still under construction and many miles of additional surveys will be run during the coming season. The Alaska survey and construction seasons are extremely short and some of the features of actual construction are unique. In many localities there is a cover known as "muskeg" which is a sort of decayed moss and humus varying in depth from a few inches to 10 feet or more. Grubbing operations along the shore require the use of heavy donkey engines mounted on scows. As rapidly as possible road-building equipment, including logging machinery, drilling apparatus, and trucks, is being delivered to Juneau, Ketchikan, and other points.

The national forest road program during the past four years has become well defined as one of the road-building requirements of the entire West and State programs of construction are planned in accordance with it, in order that through routes may develop uniformly throughout the several States. During the season of 1919 there were employed approximately 400 engineers and field assistants in the 11 Western States and it is expected that an equal number will be required before the present season's program is completed.

NEW MEXICO CONTRACTS.

It is estimated that about $1,000,000 worth of road-building contracts will be let by the State highway department of New Mexico during July. The summer will be the busiest one known in that State in road construction, especially in roads aided by the State.

HOLD LIBERTY BONDS.

Your fulfilled desires MAY NOT bring you full satisfaction; your Liberty Bond WILL bring full return of principal and interest if you hold it.

If you sell unnecessarily now, in the face of a temporary decline in price, you will not get full value either in money or satisfaction of desires.

Your Liberty Bond is as safe and sound as the Nation itself. Hold and buy more.

MONTANA ROADS.

Road construction is now under way in Montana for which the aggregate amount of the contracts is about $4,000,000. Of this amount contracts for $3,250,000 were let last fall. The State highway commission is working to add another million to the contracts for this year.

TO VOTE IN HIGHER INTEREST.

It has been decided to present to the voters of California at the November election the question of raising the rate of interest on the $40,000,000 worth of bonds voted last year from 4½ to 6 per cent. It has been found impossible to sell the bonds at the rate named in the enabling act and in the proposition submitted a year ago, and unless the rate is increased road construction under the bond issue will have to be postponed indefinitely. The Oregon plan is favored, providing for a maximum rate of 6 per cent, the rate to be fixed at the time of the sale of the bonds.

FEDERAL AID IN KANSAS.

The Kansas State highway commission has approved highways aggregating 461 miles for Federal aid. These highways represent a probable cost of $25,000,000. Contracts have been let for 162 miles, the cost of which aggregates $4,875,000. Counties are going ahead with their preliminary road work in anticipation of increased Federal aid.

There are now in file petitions for 1,345 miles of road, the estimated cost of which is in excess of $50,000,000, granting Federal aid stopped when the total reached nearly $8,000,000, the amount allotted to Kansas.

THE SELECTION AND COMPARISON OF FEDERAL-AID ROAD TYPES.

By E. W. JAMES, Assistant Chief Engineer, Bureau of Public Roads. [1]

IN the handling of Federal-aid projects the first point at which purely technical and administrative questions come squarely into contact is in the selection of the type of surface. Very frequently this contact is one of opposition. An ideal condition at this point can only exist when purely technical considerations control, and for this reason there is little hope that the ideal will ever be approximated. Furthermore, it would perhaps be unfortunate for the engineer if he were faced suddenly at the present time with such an ideal condition, for one of the large and still open questions in highway engineering is the selection of type.

Were the engineer thrown back entirely upon technical considerations, it would be found at once that data are lacking on which to come to any definite conclusion. There is some difference of opinion existing in regard to the general merit of the several types. There is little or no unity of opinion as to the service value of the various types under given conditions of traffic and no more uniform views regarding the probable length of life of the severa types. On the basis of cost over a period of years, two engineers in one of the large State highway departments have recently published articles with almost opposite conclusions regarding the order in which the higher types of pavement can be placed on the basis of ultimate economy. Data are simply not available for a purely technical answer to the question: What type of surface will give the best results under a set of given conditions?

ADMINISTRATIVE CONSIDERATIONS.

We are, however, doubtlessly moving toward the time when we will be able to make an intelligent determination of types on purely technical grounds, and the Bureau of Public Roads as the inevitable clearing house for such information, and as the only governmental organization having at its disposal funds and personnel for conducting the necessary experiments, should and will take a leading part in the necessary research to establish this detail of highway engineering on a much firmer basis than it now rests. Until such time, however, as the results of extensive investigations become available, and no doubt thereafter, it will be necessary to admit several important administrative considerations to a place when types of pavements are under consideration.

First, there are the exigencies of construction to be considered. This involves engineering administration that often meets imperative requirements and results in substantial economies. The present Federal-aid program carries a large number of projects which classify to-day as earth, sand-clay, and occasionally gravel, but which are avowedly to be completed later by the construction of more adequate surfaces. In some cases the proposed future work is a part of the original plan, but in most of the cases the work is confined to grading and necessary drainage with only such surfacing as may be required to carry traffic during a more or less short interval while the embankments are settling and reaching a condition when expensive pavements may safely be constructed upon them. In a great many projects of this kind, however, no definite plans have yet been made for the surfacing, and such questions as selection of type and raising of funds are postponed more or less indefinitely. The result is that for the present, engineering administration fixes our type as earth, sand-clay, or gravel.

Frequently in planning improvements, it is impossible at any one time to secure the necessary funds to carry out high-type work. It is quite obvious from an examination of the present Federal-aid records that in many cases counties are making their supreme financial effort to provide for the construction of a sand-clay or gravel road. Under conditions of traffic where it is obvious that a higher type of surfacing should be selected, such financial considerations which are purely administrative in nature have the effect of determining the type, regardless of what the highway engineer may recommend. As in the previous case, the final selection of type is in effect postponed until more funds are available.

Finally, and by no means least, we have the influence of local opinion which must be met and given due consideration. It is a question sometimes whether this opinion should be dignified by the name of "administrative consideration" or not, but the fact remains that it is an influence to be reckoned with wherever it occurs. The efforts of the engineer in this case should of course be in the direction of influencing the local opinion, but he is often one among many, and as he is not paying for the work his recommendations are more likely than not to be disregarded. It is at this point also that the promotion work of men having materials, equipment, or proprietary types for sale exercises its strongest influence on the selection of types. As in the other cases referred to, evidence can be found on almost every page of the Federal-aid record of projects being determined as to type, as well as to location and other details, by the influence of more or less interested local opinion.

[1] Paper read before conference of District Engineers.

DETERMINING SUITABILITY OF TYPES.

The purely administrative matters referred to thus far will doubtless always be with us, and the time is far distant when purely technical considerations will control in the selection of surfaces, but there has been nevertheless considerable work done in the direction of establishing factors for determining, with some approximation at least, the suitability of road types for service under given conditions.

For a number of years the Bureau has constructed and maintained experimental roads. Probably the most valuable work done in the course of the experiments has been on surface treatments, and considerable data, incomplete to be sure and only partly conclusive, are available.

In these studies we find, for instance, that a water-gas tar preparation applied as a cold surface treatment, maintained under patrol, will carry 925 gross tons of traffic per day, and under this traffic the maintenance will be the third in order of economy of seven experimental sections. This same section was destroyed beyond the point of any reasonable maintenance by a traffic of 1,130 gross tons per day. The nature of the effect of 1,130 tons per day was that of an overload which no amount of maintenance could remedy. The average life of a retreatment of this material is eight months. A hot tar surface treatment stood up satisfactorily under 1,325 gross tons daily average and was the sixth in order of economy in the same group of seven experiments.

There is available considerable undigested data of this kind covering seven different experimental sections. This material is now in the process of being analyzed and will probably supply valuable data for the selection of surface treated macadam. It may enable the engineer even to differentiate hot and cold treatments, tars and asphaltic oils, and possibly different asphaltic oils.

The information will in general take the form of the maximum gross tonnage-endurance of the type, the average life of retreatments, the cost of maintenance per ton of traffic, and details of successful maintenance operations.

PROBABLE LIMITING ENDURANCE.

Up to the present time the determination of type has rested largely on the judgment of each individual, so far as technical details are concerned. There is little or no material of value in the literature of highway engineering nor in the engineering press relative to the question. Engineers have written all around the subject, but have generally refrained from committing themselves to figures. We find a few attempts however, to state the probable limiting endurance of types in terms of traffic and the following indicates the result of one such attempt. The table may be headed "Limiting Economic Traffic on Types of Road Surface."

	Light wagons.	Heavy 1-horse wagons.	Heavy 2-horse wagons.	Automobiles.
Good gravel	50–75	25–30	10–12	100
Oiled gravel	.....	.....	Greater than	100
Do	75–100	30–50	20	500–700
Waterbound macadam	100–150	175–200	60–80	75
Hot oil surface treated waterbound macadam	250–300	75–100	25–30	1,400
Do	.....	Narrow tires, 100	Narrow tires, 50	Trucks, 50
Tar surface treated waterbound macadam	30–50	25–30	10–15	1,800

An older attempt at stating the limiting traffic which various types of pavement may be expected to carry economically was made by the committee on standards of the American Road Builders' Association in their report of 1915. Their tabulation follows:

Item.	Horse drawn, steel tires.		Self-propelled, rubber tires.		Self-propelled, steel tires.
	Light vehicles	Heavy vehicles, wagons, trucks.	Passenger automobile.	Motor trucks and busses.	Steam lorries and tractors.
Earth (sand)	100	75	100	.....	.....
Gravel	100–200	75–150	400 up	.....	1
Cold oil surface treated gravel	100–200	75–150	400 up	10	1
BITUMINOUS MACADAM OR CONCRETE.					
Water-bound macadam (surface treated)	100–200	75–150	100–400	10	1
Water-bound macadam (cold asphalt, oil surface treated)	100–200	75–150	100–400	10	1
Water-bound macadam (hot surface treated)	100–200	75–150	400 up	10	1
Water-bound macadam (cold tar surface treated)	100–200	75–150	400 up	10	1
Bituminous macadam (soft stone)	200 up	75–150	400 up	10–20	1
Bituminous macadam or concrete (hard stone)	200 up	150 up	400 up	10–20	2–6
Concrete	100–200	75–150	400 up	10–20	.....
Vitrified brick stone sets or wood block	200 up	150 up	400 up	20 up	6 up.

It is noteworthy that the above indicates that certain types of surfaces may be depended upon to carry somewhat more than is indicated by the careful experimental work of the bureau. But the range of type in the first table is so limited that it is of little general use, although it fairly represents the best data of the kind available. The table furnished by the Road Builders' Association is altogether too uniform in its enumeration of traffic and for steel-tired vehicles on the lower types of surfaces is much higher than appears to be warranted.

With respect to heavy trucking, the observations of this bureau are that the effect of trucks rated heavier than 3 tons is generally seriously destructive of any type of pavement designs customarily used on rural roads up to 1917. Further, the destructiveness varies directly with the speed, but probably in greater ratio. It appears that constant use of a few trucks per day, if they are heavier than 3 tons and run at high speed, say 25 to 35 miles per hour, is sufficient to cause high-type pavements of designs current in 1916 to fail as by overload. It is not a question of adequate or economical maintenance in such cases, but of out-and-out pavement failure.

IMPACT A DESTRUCTIVE FORCE.

Within the last two years we have been compelled to give recognition to a new destructive force affecting road surfaces. Impact, almost never formerly considered by the highway engineer, is now a force to be reckoned with. It has a close application to the determination of types for certain kinds of traffic, and as high-speed motor trucks are increasing in number rapidly and becoming more generally used, the question of the effect of impact is a serious problem. The bureau is at work determining the force of impact developed by trucks under a variety of conditions. Parallel with these investigations impact test experiments are now ready which, it is hoped, will indicate to some known degree of accuracy the amount of impact which different types of pavement will successfully resist. The correlation of these two sets of experiments should furnish some data useful to the solution of the question: How much truck traffic will a given type stand without failure?

Other experiments to determine the effect of abrasion on pavement surfaces are also underway, and these will furnish further data useful in the selection of types. Obviously, if these experiments are fruitful in results, the engineer will be in a much better position a year from now to face the purely technical considerations involved in the selection of pavements.

ALTERNATE DESIGNS.

On Federal-aid work probably every district engineer has observed that the question of the selection of types is not the only perplexing matter connected with the subject. There has been during the past two years a continual increase in the practice of using alternate designs on projects submitted. This practice was not common when Federal aid was first inaugurated, but beginning with Indiana, in which State the law requires that tenders shall be asked on at least two alternate types, and with Ohio and Pennsylvania, which states adopted a policy of securing bids on alternate types, the practice has rapidly expanded until to-day Federal-aid projects, involving the higher types of design, come to the Bureau more often with alternate designs than with a single type. This fact is borne out by the statistics of Federal-aid mileage. At one time when an examination of the records was made for this purpose 12.8 per cent, representing 963.65 miles, was undetermined. Practically all of this mileage was undetermined because a decision as to the type had not been made and would not be made until after bids had been received. This does not represent all of the alternate work undertaken, as a considerable mileage entered under other types had originally been submitted in alternate form and adjusted when award was made. Obviously therefore, the question of alternate types has become a serious one in mere quantity, and because of the extraordinary questions involved appears likely to result in some very troublesome questions of policy and administration for the Bureau.

METHODS OF COMPARING TYPES.

The problem has come before the Bureau from so many different angles that it appears almost hopeless to attempt a solution along any of the lines heretofore suggested.

In the first place, Illinois has attempted to set up a rational method of comparing types with at least one very interesting result. Although the conclusion reached is not satisfactory to many engineers and certainly not to a large group of material manufacturers, there has, nevertheless, been surprisingly little unfavorable criticism of the Illinois conclusion, either among engineers or in the engineering press. The reason for this is quite clear—for neither the engineers nor the editors have any better data on which to base objections than the Illinois department had on which to base their conclusions, and the attitude of all concerned appears to be very largely one of "hands off." The essential feature of the Illinois conclusion is that, studied as a beam, a pavement cross section wholly of concrete is stronger than black top on an adequate base of concrete. The upper layers or wearing surface of a pavement cross-section in concrete is worth twice as much as a black-top wearing surface. Incidental to this conclusion is the use of an identical mix for a one-course concrete design and for the base of black-top construction. Obviously, a rational analysis of this problem has not been made and would be of very doubtful value. It appears to involve the analysis of a compound beam of elastic material continuously, but not uniformly, supported on elastic bearings, and besides the question of flexure involves consideration of no less than three different longitudinal shears, one in concrete, one in black top, and one in the joint between them. The last element can not possibly be evaluated, and the question of reduced impact, owing to the cushioning effect of the black top, confuses the whole problem.

Another method suggested and used by the State of Pennsylvania in the specification current during 1919 is to establish comparable types on the basis of probable cost. For this reason, Pennsylvania in the standard specifications for 1917, developed designs for such pavements as sheet asphalt, Filbertine and Warrenite, having dimensions which depart from previous customary practice. These designs were built up with the sole end in view of producing a cross-section in each type of substantially equal money value. Obviously, the problem is reduced to a hopeless dilemma by attempting a solution of this kind, because if on the basis of cost a logical solution is attempted it must be revised as the costs of materials vary, but in so doing it becomes distinctly illogical from the technical viewpoint.

Another solution of the problem of comparable and alternate types which has been tentatively followed by this Bureau starts by establishing a list of pavements on the basis of service value. This is purely empirical and indeterminate because it is likely to vary somewhat in the judgment of different engineers. The order in which pavements have been listed by the Bureau is as follows:

Brick on a concrete base.
Sheet asphalt on a concrete base.
Cement concrete.
Bituminous concrete on an adequate base.
Bituminous macadam.
Surface-treated macadam.
Waterbound macadam.
Gravel macadam.
Gravel.
Sand clay.
Top soil.
Earth.

GROUP CLASSIFICATION OF TYPES.

Quite clearly there may be a difference of opinion as to the position of cement concrete and bituminous concrete in the above list, and it is equally clear that a lower type may, by superior detail of design, be made to excel a higher type in the list. The next step, therefore, was to attempt to indicate sufficiently the details of design so that the pavements could be classified in groups. This classification follows:

Class A for heavy traffic:

(1) Monolithic or semimonolithic brick pavement using 3-inch or 3½-inch block on cement concrete base, 4 or 5 inches deep, 1–2½–5, or 1–3–6 mix.
(2) Bituminous concrete, 2 inches thick, on a 6 or 5 inch cement concrete base, 1–3–6 mix.
(3) Cement concrete pavement, 6 inches thick at the sides and 7½ inches at the center, 1–2–4 mix.

Class B for medium traffic:

(1) Bituminous concrete, 1½ inches thick, on a cement concrete base 4 to 5 inches thick, 1–3–6 mix.
(2) Cement concrete pavement, 5 by 6½ inches, 1–2–4 mix.
(3) Bituminous concrete, 2 inches thick, on a 4-inch bituminous concrete base of crushed stone or gravel.

Class C for light traffic:

(1) Bituminous concrete, 1½ inches thick, on a bituminous concrete base, 4 inches deep, of crushed stone or gravel.
(2) Bituminous concrete, 1½ inches thick, a bituminous binder course 1½ to 2 inches thick, on a 4-inch broken-stone base.
(3) Bituminous concrete, 2 inches thick, on a waterbound macadam base 5 inches thick.
(4) Bituminous macadam, 2½ inches thick, on a 5-inch waterbound macadam.

This classification was especially devised as a suggestion for the State of Idaho, and there was included under class A for heavy traffic as a fourth alternate, bituminous concrete, 2 inches deep, on a 6-inch or 5-inch bituminous concrete base of crushed stone. This addition was solely for the purpose of providing in this group a type of surface that did not require water in the building. Consideration of these groups indicates at once that the classification is not of a kind to be generally applicable. Class A pavements would be made considerably heavier in most of the Eastern States and numerous other variations in detail would have to be made for other localities.

So many different questions have arisen regarding the determination of alternate and comparable types that it appears necessary to seek a solution in an entirely different direction. So far we have attempted to establish an equivalency of either cost or service value. It is doubtful whether this is possible in the light of our present knowledge and it appears likely that when further data is available this doubt will be converted into a certainty.

DIFFERENTIALS AMONG TYPES.

It has, therefore, been suggested that an attempt be made to establish normal differentials among the several higher types that are likely to be brought together in competition. This normal differential presupposes the fixing of what may be referred to as a normal base price for each type on a given project, and this will be arrived at by a careful analysis of the materials entering into the construction of the design on the basis of their cost. Given a particular project on which it is intended to solicit tenders for sheet asphalt, modified Topeka, and concrete, the materials necessary to construct each type will be located and the cost of placing them into the work will be analyzed. This will provide for each type a very carefully compiled engineer's preliminary estimate. It need not represent the actual cost, but it will establish a normal basis of comparison and fix the normal differentials that may be expected to exist between various types. This will be done, of course, in advance of the bidding, and the engineer, and assumably prospective contractors, will have advance knowledge of these differentials.

When the bids are opened, if the bid for concrete is below its normal base price and the bid for Topeka is above its normal base price, the concrete would be considered the better bid. If, on the other hand, sheet asphalt, although bid at a considerably higher cost, were below its normal base price, and concrete above its normal base price, the tender for sheet asphalt could logically be considered as the better bid. Assuming, therefore, that in the premises the types have all been established as adequate and reasonable for the traffic likely to develop on that particular project, then the engineer would be logically justified in awarding a contract to sheet asphalt, although it might be the highest bid in dollars and cents. The practical effect of this method is to avoid a decision as to strictly comparable types or designs, and at the same time maintain competition. But that competition is no longer *among the types;* it is a competition of each type *with its normal* or base estimate.

WORKING OUT THIS SUGGESTION.

It is, of course, at once apparent that a suggestion of this kind can only be worked out under very intelligent engineering direction. The policy of blindly assuming costs based on previous averages of bids must be abandoned. Likewise, the custom so apparent now in Federal aid estimates of assuming a single price of $2.75 or $3.50 for surface, regardless of the

type, simply for the purpose of establishing a preliminary estimate will have to be discarded. It will mean that the engineer after having selected his alternative designs will first have to compute the quantities of cement, sand, chips, aggregate, bitumen, filler, and whatever other materials enter into the construction, locate probable sources of suitable materials, and carefully analyze the cost of each one. The organization of a mixer gang will have to be known within a narrow margin, based on the probable method of construction prevailing and likely to continue in the particular locality. Similarly, any construction organization which may be required by the design selected will have to be understood and labor costs analyzed. It is probably not possible to generalize in these matters and estimates would be required for each project coming under consideration.

Whether this scheme is practicable from a business point of view may be open to some question. It has some decided advantages. For instance, it has been noticed that concrete bids when brought into competition with bids for Topeka or Warrenite on a concrete base have a marked tendency to rise until they are only slightly below the Topeka bids. If a differential were established concrete would have to stay down where it belongs or it would be at a disadvantage. The cost of preparing preliminary estimates would be somewhat greater than at present and the estimates could not be based so generally on averages derived from records of past bids as they now are. It is probable also that a somewhat higher standard of preliminary engineering in general would be required to carry out this scheme successfully because there would doubtless arise considerable differences, especially among material men, as to the fairness of the differentials established and the engineer responsible for the computations would have to fortify his conclusions by very skillfully analyzed data.

FEDERAL AID ALLOWANCES.

PROJECT STATEMENTS APPROVED IN MAY, 1920.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Estimated cost.	Federal aid.
Arizona	29	Pima	8.852	Concrete	May 3	$347,159.23	$173,579.61
	30	Maricopa	3.000	....do	May 6	98,596.08	49,298.04
	24	Coconino	14.860	Gravel	May 26	138,688.00	69,344.00
Arkansas	74	Searcy		Bridge	...do	34,650.00	15,600.00
California	59	San Luis Obispo	11.540	Concrete	May 11	311,828.00	155,914.00
	58	Santa Barbara	14.640	....do	May 25	440,814.00	220,407.00
	57	Tehama	13.600	....do	May 26	241,395.00	120,697.50
Colorado	96	Otero	1.515	....do	May 4	76,276.20	36,615.50
	118	El Paso	2.763	....do	May 26	135,451.80	55,260.00
	19	Powers	2.024	Gravel	May 28	19,963.07	9,981.53
	59	Bent	10.000	....do	...do	89,522.01	44,761.00
	86	Larimer	1.386	Concrete	...do	56,068.10	27,720.00
	112	Park	0.909	Gravel	...do	29,109.05	14,554.52
Georgia	142	Thomas	8.900	Sand clay	May 4	64,350.00	32,175.00
	146	Tift	6.000	Paved	May 7	181,154.05	50,000.00
	137	Bibb	4.000	Concrete	May 11	141,940.99	55,000.00
	144	Macon	3.750	Sand clay	...do	8,373.64	4,186.80
	143	Laurens		Bridge	May 25	103,315.88	50,000.08
	150	Washington	8.300	Sand clay	...do	62,424.19	30,000.00
	145	Montgomery	12.000	....do	May 11	60,434.00	30,000.00
	149	Telfair	9.810	....do	May 26	60,370.42	21,000.00
	147	Troup	13.240	Top soil	May 28	121,578.42	50,000.00
	151	Floyd	7.000	....do	...do	44,218.57	22,109.22
	158	Twiggs	8.990	....do	...do	48,056.03	21,000.00
	118	Fannin	[1]1.953	Earth	May 25	[1]57,500.71	[1]29,550.75
Idaho	42	Gooding	5.350	Crushed rock	May 4	52,999.54	26,499.77
Indiana	25	Miami		Bridge	May 28	13,007.50	6,503.75
Iowa	68	Dickinson	5.000	Paved	...do	247,445.00	100,000.00
	128	Johnson	2.500	....do	...do	115,060.00	50,000.00
	18	Clinton	[2]0.721	....do	May 7	[1]820,940.34	[1]323,813.55
Kansas	57	Marshall	30.500	Concrete or gravel, bituminous	May 3	1,472,927.50	147,500.00
	56	Gray	6.000	Gravel	May 11	69,991.90	28,750.00
	58	Shawnee	7.930	Brick, concrete, or bituminous macadam	May 24	459,415.00	75,150.00
Kentucky	29	Laurel	16.166	Macadam	May 5	275,797 94	137,898.97
	24	Jessamine	3.960	Waterbound macadam, surface treated	May 28	[1]40,333.55	[2]20,166.77
Maine	29	Androscogin	5.260	Bituminous macadam	May 7	193,479.00	96,739.50
	28	Sagadahoc	1.340	....do	May 11	45,870.00	22,935.00
	34	Oxford	4.570	Concrete	...do	188,199.55	91,400.00
Massachusetts	37	Berkshire	1.164	Bituminous macadam	May 4	48,042.50	23,280.00
	38	Essex	2.827	....do	May 6	149,699.00	56,540.00
	35	....do	4.572	Concrete	May 4	224,455.00	91,440 00
Michigan	37	Hillsdale and Calhoun	11.637	Concrete and gravel	May 28	235,620.00	117,810.00
Minnesota	163	Rock	6.000	Gravel	May 3	40,095.00	20,047.50
	120	Aitkin	8.050	....do	...do	45,012.00	22,506.00
	164	Traverse	15.400	....do	May 4	110,024.20	55,012.10
	131	Douglas	14.070	....do	May 5	78,360.70	39,180.35
Minnesota	98	Todd	19.570	....do	May 12	102,740.00	51,370.00
	139	Lyon	8.000	....do	...do	97,020.00	48,510.00
	145	Pope	14.850	....do	May 11	105,193.00	52,596.50
	165	Wright	14.000	....do	...do	130,020.00	65,010.00
	166	....do	5.300	....do	May 12	48,994.00	24,497.00
	168	Itasca	8.430	Concrete, brick or asphalt	May 11	346,568.64	168,600.00
	129	Clay	27.740	Earth	May 28	109,428.00	54,714.00
	140	Cass	12.600	Gravel	...do	83,314.00	41,657.00
	141	....do	5.500	....do	...do	41,470.00	20,735.00
	151	Kittson	15.750	....do	...do	89,848.00	44,924.00
	155	Polk	13.500	....do	...do	90,847.35	45,423.67
	167	Hubbard	9.000	....do	...do	56,930.72	28,465.36
	173	Dodge	3.980	....do	...do	44,326.70	22,163.35
	174	....do	3.000	....do	...do	43,120.00	21,560.00

[1] Revised statement. Figures given are increases over those given in the original statement.
[2] Revised statement. Mileage given is a decrease from that in original statement.

PROJECT STATEMENTS APPROVED IN MAY, 1920—Continued.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Estimated cost.	Federal aid.
Mississippi	49	Coahoma	10.680	Concrete	May 3	$320,485.44	$100,000.00
	96	Sunflower	5.180	....do	....do	160,380.00	80,190.00
Missouri	99	Clay	10.600	Bituminous macadam	May 11	253,322.47	126,661.23
	26	Dunklin	8.620	Gravel	....do	118,023.81	59,011.90
	102	Cedar	5.550	Chat	May 28	49,718.60	24,859.30
	108	Grundy	5.000	Earth	....do	41,145.50	20,572.75
	114	Lawrence	8.000	Gravel or chat	....do	18,046.21	9,023.10
	116	Grundy	7.450	Earth	....do	187,877.80	93,938.90
	117	Henry	6.480	Chat	....do	71,694.00	35,847.00
	120	Mew Madrid	3.500	Gravel	....do	61,274.40	30,637.20
	123	Andrew	0.514	Bituminous macadam	....do	11,694.10	5,847.05
Montana	71	Musselshell	0.660	Earth	....do	19,847.00	9,923.50
	109	Stillwater	5.200	Gravel and earth	....do	92,452.63	46,226.31
Nebraska	107	Cass, Saunders, and Sarpy	32.000	Earth	May 3	177,100.00	88,550.00
	149	Cheyenne	36.300	....do	May 28	137,929.00	68,964.50
	148	Gopher and Frontier	36.800	....do	....do	141,724.00	70,862.00
New Hampshire	112	Cheshire	0.260	Gravel	May 4	10,000.00	5,000.00
	95	....do	0.810	Gravel and bituminous macadam	....do	15,000.00	7,500.00
	98	....do	0.625	Gravel	May 3	11,999.99	5,999.99
	117	Grafton	0.940	Bituminous macadam	May 28	25,000.00	12,500.00
	99	Coos	1.100	Gravel	....do	18,000.00	9,000.00
New Jersey	28	Camden	[2]4.907	Concrete	May 26	[2]26,949.54	[2]98,140.00
	23	Mercer	[2]0.626	....do	May 13	[3]47,295.38	[2]12,520.00
New Mexico	31	Sierra	4.220	Gravel	May 11	25,457.90	12,728.95
	49	Otero	11.600	Caliche	May 28	77,036.30	38,518.15
New York	45	Orleans	3.300	Concrete	May 6	132,000.00	66,000.00
	62	Chenango	0.750	....do	....do	74,000.00	19,000.00
	63	Tompkins	4.600	Bituminous macadam	....do	174,800.00	87,600.00
	64	Suffolk	9.200	Concrete	....do	368,000.00	184,000.00
	65	Otsego and Schoharie	10.700	....do	May 12	428,000.00	214,000.00
North Carolina	140	Robeson	38.500	Top soil	May 3	312,950.00	156,475.00
	136	Dare	7.000	....do	May 26	52,684.50	26,342.25
North Dakota	63	McLean	10.000	Earth	May 3	31,900.00	15,950.00
	66	Sargent	6.375	....do	May 5	23,760.00	11,880.00
	94	La Moure	15.000	....do	May 12	47,080.00	23,540.00
	96	Ramsey	9.000	....do	May 3	25,300.00	12,650.00
	97	McIntosh	12.000	....do	May 6	40,020.00	20,010.00
	98	Benson	15.000	....do	May 3	48,950.00	24,475.00
	99	Griggs	2.500	....do	May 11	7,480.00	3,740.00
	101	Foster	6.000	....do	May 26	16,632.00	8,316.00
	102	....do	3.500	....do	May 11	9,702.00	4,851.00
	93	La Moure	8.000	....do	May 28	25,696.00	12,848.00
	39	Grant	0.500	....do	May 6	[1]34,000.00	[1]18,848.42
Ohio	125	Auglaize	2.940	Concrete	May 12	115,000.00	35,000.00
	126	Preble	4.170	Brick	May 11	216,000.00	31,000.00
	109	Clark	6.220	Concrete	May 28	360,600.00	61,000.00
	110	....do	9.100	....do	....do	395,000.00	89,000.00
	123	Miami	4.670	....do	....do	172,000.00	46,700.00
	124	Auglaize	5.306	....do	....do	220,000.00	72,000.00
	143	Logan	5.600	....do	....do	248,000.00	85,000.00
	108	Meigs	10.150	Earth	....do	224,000.00	112,000.00
	154	Clermont	3.548	Macadam	....do	104,600.00	39,320.00
Pennsylvania	77	Monroe	7.280	Concrete	May 4	450,572.36	145,600.00
	82	Erie	8.466	....do	....do	502,789.26	169,320.00
	83	Montgomery	4.907	....do	....do	265,732.67	98,140.00
	84	Tioga	3.865	....do	....do	352,523.52	77,300.00
	79	Montgomery	5.655	....do	May 3	313,752.94	113,100.00
	81	Tioga	3.966	Bituminous or concrete	May 4	354,394.26	79,320.00
	80	Crawford	3.432	Concrete	May 11	221,091.35	68,640.00
	74	Northampton	6.610	....do	May 25	357,289.57	132,200.00
Rhode Island	10	Newport	2.030	Bituminous macadam	May 7	114,000.60	40,600.00
	9	Washington	2.290	Concrete	May 26	125,411.20	45,800.00
South Carolina	94	Union	3.873	Top soil	May 5	23,521.89	4,200.00
	104	Calhoun	1.200	Concrete or macadam	May 28	70,621.65	23,665.04
South Dakota	55	Deuel	9.600	Gravel	May 3	63,155.40	31,577.70
	58	Codington	18.200	....do	May 5	122,489.40	61,244.70
	57	Jones	7.580	Earth	May 3	48,338.40	24,169.20
Tennessee	25	Giles	19.087	Bituminous macadam	May 28	519,688.14	259,844.07
Texas	157	Galveston	1.500	Brick	May 3	101,050.40	30,000.00
	125	Liberty	8.518	Gravel	May 6	136,596.44	65,000.00
	151	Bee	21.919	Bituminous	May 7	426,547.86	200,000.00
	152	Upshur	25.900	Gravel	May 11	228,635.77	114,317.88
	49	Nolan	[2]13.700	....do	May 18	[2]43,709.60	[2]21,854.80
	44	Robertson	[2]5.500	....do	May 8	[2]27,890.50	[2]13,945.25
Utah	30	Weber	7.371	Bituminous concrete	May 25	268,450.05	134,225.02
	29	Sanpete	1.230	Hard	....do	[1]47,160.30	[1]23,380.15
Virginia	79	Stafford and Prince William	0.550	Concrete	May 5	39,710.00	14,000.00
	66	Chesterfield	8.940	....do	May 4	352,682.00	176,341.00
Washington	68	Grant	3.340	Gravel or crushed rock	May 7	51,475.16	25,000.00
	67	Mason	5.540	Gravel	May 11	118,640.92	59,320.46
	70	Lewis	3.960	Earth	....do	95,140.65	46,000.00
	66	Garfield	7.470	Concrete	....do	215,216.65	100,000.00
	64	Snohomish	0.990	....do	May 26	39,695.26	19,800.00
West Virginia	97	Marshall	3.000	....do	May 28	136,643.00	16,843.00
Wisconsin	118	Ashland	1.400	Macadam	May 6	15,468.97	5,400.00
	148	Waushara	4.380	Gravel	May 4	45,093.76	15,557.00
	158	Iron	5.350	Earth	May 11	39,000.00	14,500.00
	132	Marquette	4.600	Top soil	....do	42,211.67	14,950.00
	167	Lincoln	5.520	Gravel	....do	48,000.00	16,500.00
	113	Douglas	5.800	Concrete	May 25	283,417.17	95,275.97
	130	Price	5.510	Earth	....do	55,050.00	18,350.00
	146	Vilas	5.670	Gravel	....do	60,000.18	22,000.00
	170	Oneida	4.660	....do	....do	45,000.00	15,300.00
	160	Waukesha	2.240	Concrete	May 28	78,577.51	28,300.00
	76	Portage	[2]6.370	Gravel	May 12	[2]31,019.23	[2]10,339.74
Wyoming	86	Johnson	6.477	Selected material	May 11	78,870.00	39,435.00
	75	Uinta	2.489	....do	....do	18,425.00	9,212.50
	82	Laramie and Goshen	22.861	....do	May 25	207,240.00	103,620.00
	84	Park	6.951	Earth	....do	56,650.00	28,325.00
	30	Natrona	4.106	Concrete	May 28	180,510.00	90,255.00
	83	Sheridan	14.129	Selected material	....do	153,835.00	76,917.50
	85	Natrona	10.000	....do	....do	92,125.00	46,062.50
	41	Crook	10.089	Earth	May 26	[1]47,740.00	[1]23,870.00

[1] Revised statement. Figures are increases over those given in the original statement.

[3] Withdrawn.

PROJECT AGREEMENTS EXECUTED IN MAY, 1920.

State.	Project No.	County.	Length in miles.	Type of construction.	Project agreement signed.	Estimated cost.	Federal aid.
Arizona	10	Maricopa		Bridge	May 6	$54,970.74	$27,485.37
	14	Cochise	13.560	Gravel	May 12	112,213.35	56,106.67
	11	....do	8.464	Concrete	May 11	297,081.14	148,540.57
	5	Mohave	2.186	Gravel	May 17	76,151.90	38,075.95
	3	Navajo and Apache	.498	....do	May 12	[1] 19,725.38	[1] 9,862.69
Arkansas	46	Grant	12.480	....do	May 25	32,595.36	12,000.00
	51	Conway	6.030	Bituminous, macadam	...do	107,772.28	49,156.00
California	39	Riverside	14.330	Reinforced concrete	May 12	356,735.53	178,367.76
	43	Mariposa	1.280	Earth	...do	38,004.14	19,002.07
Colorado	36	Boulder	1.182	Concrete	May 11	46,607.27	23,303.63
	37	....do	.814	....do	...do	47,424.13	23,712.06
	77	Mesa	2.496	....do	...do	113,743.05	49,920.00
	17	El Paso	2.339	Earth	May 14	53,167.90	26,583.95
	33	Larimer	1.962	Concrete	...do	74,494.25	37,247.12
	65	Ouray	1.155	Earth	...do	67,775.89	24,698.16
Delaware	2	Sussex		Concrete	May 6		17,290.61
Florida	8	Alachua	11.675	Bituminous, macadam	May 12	204,018.80	102,009.40
	14A	Santa Rosa	6.318	Grouted brick	...do	130,158.87	65,079.43
Georgia	56	Gwinnett	12.000	Top soil	...do	70,380.56	35,000.00
	88A	Brooks	4.550	Concrete, sand-clay	...do	116,223.49	58,111.62
	43	Habersham	4.648	Bituminous, macadam	May 11	20,888.19	10,444.09
	94A	Dooly	7.620	Sand-clay	...do	50,180.37	25,090.18
	106	Sumter	3.000	Penetration, macadam	May 15	86,345.51	20,015.92
	99A	Thomas	2.500	Bituminous, macadam	May 28	85,482.10	42,741.05
	107A	Worth	2.750	Kentucky rock, asphalt	...do	100,000.00	50,000.00
	75	Gilmer	.537	Concrete and waterbound macadam	May 22	21,108.80	10,526.45
	90A	Cook	8.106	Paving	...do	270,385.19	103,000.00
	10	Towns		Earth	May 20	[1] 20,195.87	[1] 10,117.36
	28	Paulding		....do	May 15	[1] 18,945.86	[1] 9,580.88
Illinois	1-2	Dupage	.435	Concrete	May 24	[1] 12,906.42	[1] 13,437.10
	1-3	....do		....do	...do	[2] 10,174.56	[2] 13,353.18
	1-6	Kane and Dekalb		....do	...do	[1] 21,016.56	[1] 18,251.20
	1-9	Ogle and Dekalb		....do	...do	[1] 14,683.77	[1] 22,123.11
	2-2	Iroquois		....do	May 12	[1] 45,717.86	[1] 44,189.04
	2-7	....do	.589	....do	...do	[1] 45,175.10	[1] 47,492.56
Indiana	20	Ripley	.977	....do	May 10	49,690.37	19,540.00
Iowa	48	Humboldt	1.850	Brick, concrete, or gravel	May 15	88,588.35	28,127.50
	62	Blackhawk	17.170	Brick or concrete	...do	818,376.51	343,400.00
	111	Kossuth	21.312	....do	...do	995,001.59	426,200.00
	115	Cerro Gordo	22.070	....do	...do	1,040,894.72	441,400.00
	23	Marshall	5.928	....do	...do	272,322.05	118,500.00
	30	Winnebago	7.450	Gravel	...do	50,813.34	25,400.00
	43	O'Brien	22.500	Brick or concrete	...do	1,063,248.45	450,000.00
	89	Polk	7.220	....do	...do	340,179.67	144,400.00
	109	Palo Alto	11.050	....do	...do	339,153.65	169,500.00
	114	Scott	17.114	....do	...do	913,901.12	340,000.00
	42	Wapello	10.500	Earth	...do	90,646.27	45,300.00
	22	Linn	.009	Gravel and earth	...do	[1] 207,496.85	[1] 136,032.18
	5	Buchanan	.040	Gravel and concrete	...do	[1] 647,330.52	[1] 289,058.65
Kansas	3ABC	Barton	22.083	Brick and concrete	May 11	1,504,566.09	331,245.00
	33B	Bourbon	4.595	Bituminous macadam	May 12	149,355.83	68,925.00
	42	Meade	5.309	Earth	...do	51,077.33	25,538.66
	49	Ottawa	5.484	Brick or concrete	...do	358,569.84	81,250.00
	50	Bourbon	.520	Bituminous macadam	...do	16,208.58	7,800.00
	43	Wilson	24.834	Gravel	May 19	579,561.86	147,500.00
Kentucky	16A	Warren	1.949	Rock asphalt macadam	May 12	49,999.84	24,999.92
	9A	Todd	4.274	Waterbound macadam	May 11	73,142.87	36,571.43
Louisiana	64	Concordia	8.980	Gravel with clay binder	May 20	153,898.54	76,949.27
	47	East Carroll	35.060	Gravel	May 28	412,455.01	206,227.50
Maine	5	Washington	5.182	....do	May 11	84,255.27	42,127.63
	1	Sagadahoc		Bituminous macadam	...do		[1] 13,194.65
Massachusetts	17	Essex	1.794	....do	...do	63,125.86	31,562.93
	18	Worcester	2.797	Concrete	...do	117,690.10	55,940.00
	25	Middlesex	.597	....do	...do	82,641.35	38,389.77
	28B	Berkshire	2.690	....do	...do	109,772.85	53,800.00
	31	Essex	1.107	Bituminous macadam	...do	45,544.87	22,140.00
Minnesota	84	St. Louis	1.130	Concrete	May 12	59,625.72	20,000.00
	75	Murray	17.700	Gravel	May 20	156,489.52	50,000.00
	113	Crow Wing	3.340	Concrete	May 18	110,967.50	31,860.30
	37	Hennepin	5.510	Asphaltic concrete	May 28	202,168.26	40,000.00
	112	Polk	1.356	Concrete	...do	51,180.80	25,000.00
	11	Goodhue		Gravel	May 24	[1] 6,524.22	[1] 10,227.68
	81	Marshall		....do	May 17	[1] 49,190.04	[1] 35,000.00
	3	Mille Lacs		....do	May 12	[1] 42,508.98	[1] 34,000.00
Mississippi	80	Adams	3.600	....do	May 11	49,648.34	24,824.17
	10	Lincoln		....do	May 12	[1] 45,695.52	[1] 22,857.36
Missouri	43	Montgomery	8.241	Macadam	...do	61,993.22	30,996.61
	56	Jasper	4.030	Concrete	...do	103,555.66	51,777.83
	83	Jasper and Newton	9.440	....do	...do	244,242.04	122,121.02
	30	Morgan	11.077	Gravel	May 25	83,159.12	41,579.56
	14	Buchanan	10.710	Brick on concrete base, asphalt concrete, and concrete.	May 28	546,575.48	136,643.87
Montana	22	Ravalli	4.340	Gravel	May 6	25,215.20	12,607.60
	92A	Granite	1.136	Earth	May 25	48,646.51	22,720.00
Nebraska	85A	Valley	13.390	....do	May 10	86,641.79	43,320.89
	68A	Hitchcock	4.460	....do	...do	62,583.56	31,291.78
	88A	Cuming	3.340	Sand gumbo	...do	45,090.01	22,545.00
	103	Scotts Bluff		Bridge	...do	150,083.71	75,041.85
	121A	Perkins	8.930	Earth and sand-clay	May 13	50,714.19	25,357.09
	125A	Brown	7.760	Earth	May 8	75,988.46	37,994.23
	42A	Custer and Loup	5.930	....do	May 13	69,317.51	34,658.75
	54	Deuel	10.960	....do	...do	42,373.32	21,186.66
	79	Morrill	13.390	Earth and sand-clay	...do	62,044.40	31,022.20
	104	Hall	3.013	Earth	...do	11,791.10	5,895.55
	58A	Colfax	1.416	Concrete and earth	May 24	84,435.25	28,332.00
	7	Kearney, Adams, Clay, Nuckolls.		Earth	May 10	[1] 48,211.35	[1] 24,105.68
	50	Merrick and Nance		Earth and sand-clay	May 8	[1] 23,933.09	[1] 11,966.55
	78	Douglas		Earth	May 10	[1] 15,106.68	[1] 7,553.34
	100	....do		....do	May 8	[1] 10,373.89	[1] 5,186.95
	52	Phelps		Gravel clay	May 10	[1] 17,563.54	[1] 8,781.77
	40	Thayer		Earth	May 13	[1] 9,805.64	[1] 4,902.82
	75	....do		....do	May 10	[1] 20,528.99	[1] 10,264.50

[1] Modified agreements. Amounts given are increases over those in the original agreement. [2] Modified agreements. Increase. Revised statement.

PROJECT AGREEMENTS EXECUTED IN MAY, 1920—Continued.

State.	Project No.	County.	Length in miles.	Type of construction.	Project agreement signed.	Estimated cost.	Federal aid.
New Hampshire	88	Hillsborough	1.450	Gravel	May 4	$25,137.97	$12,568.98
	106	do	.379	do	May 6	8,363.30	4,181.65
	90	do	1.300	Modified asphalt	May 10	26,138.64	13,069.32
New Jersey	17A	Burlington	3.313	Concrete	May 19	266,322.13	66,260.00
	19	Mercer and Middlesex	1.440	do	do	122,382.37	28,800.00
	13	Salem and Gloucester	7.248	do	do	336,689.32	144,960.00
New Mexico	20	Lincoln	7.880	Gravel	May 12	109,173.39	54,586.69
New York	24	Herkimer	3.250	Reinforced concrete	May 28	114,470.00	57,235.00
North Carolina	60	Lenoir	7.880	Concrete	May 6	284,725.35	26,249.23
	45	Buncombe		do	May 15	[1] 143,078.27	[1] 71,539.14
	38	Rockingham		Topsoil	May 8	[1] 12,041.10	[1] 10,514.32
	18	Alexander		Sand clay	do		[1] 8,223.24
North Dakota	31	Lamoure		Gravel	May 14	[1] 3,883.19	[1] 1,941.59
	3	Williams		Earth	May 6	[2] 14,344.98	[2] 7,172.49
Ohio	136	Clermont	2.542	Bituminous or waterbound macadam	May 21	73,100.00	35,000.00
Oklahoma	9	Le Flore		Bridge	May 11	33,934.73	16,967.36
Oregon	17	Malheur	9.260	Earth	May 7	115,462.16	57,731.08
	22	Clatsop		Bridge	do	339,482.66	169,741.33
	24	Gilliam	14.950	Earth	do	231,035.31	115,517.65
	25	Sherman	14.810	do	do	226,836.77	113,418.38
	26	Klamath	8.960	Broken-stone macadam	do	144,315.93	72,157.96
	27	Columbia	10.870	Bituminous concrete	do	315,847.07	157,923.53
	31	Klamath	14.680	Gravel	May 25	170,535.25	85,267.62
	34	do	12.800	Broken stone and gravel macadam	do	127,138.99	63,569.49
Pennsylvania	57	Clearfield	2.448	Reinforced concrete	May 11	142,076.55	48,960.00
	68	York	6.052	do	do	319,409.42	121,040.00
	69	do	4.878	do	do	280,574.39	97,560.00
	70	Adams	5.594	do	do	333,634.78	111,880.00
Rhode Island	6	Providence	2.920	Bituminous concrete	May 12	121,331.54	58,400.00
	7	Newport	2.560	Bituminous macadam	do	113,019.50	51,200.00
South Carolina	10A	Lancaster	15.447	Gravel	do	147,729.27	56,810.77
	82 A B & C	Union	16.785	Topsoil	May 11	110,289.86	55,144.93
	5	Chesterfield		Gravel	May 18	[2] 7,633.94	[2] 3,816.97
	20	Cherokee		Topsoil	May 3	[1] 19,557.40	[1] 9,777.70
South Dakota	9	Brown		Gravel	May 21	[1] 10,940.53	[1] 5,470.26
Tennessee	21	Carroll	12.270	Chert	May 12	238,279.39	119,139.69
	6	Washington		Waterbound macadam	May 28	[1] 113,039.76	[1] 56,519.88
	2	Hamilton		do	May 13	[1] 31,534.09	[1] 15,767.05
Texas	56B	Jefferson	2.350	Gravel and rock asphalt	May 15	70,200.00	35,100.00
	106	Brazoria	9.440	Oyster mud shell	May 11	156,671.44	39,169.89
	116	Tom Green	26.540	Waterbound macadam	May 15	332,856.32	100,000.00
	51	Madison	20.260	Earth	do	113,977.11	43,494.28
	109	Wood	21.690	Gravel	do	168,214.84	63,500.00
	101	Bowie		do	May 18	[1] 5,837.86	[1] 2,698.91
	79	Caldwell		do	do	[1] 2,663.65	[1] 1,010.13
	49	Nolan	11.840	do	do	[3] 65,191.04	[3] 32,595.52
	52	Callahan		Gravel and waterbound macadam	May 15	[4] 107,834.44	[4] 25,000.00
	4	Travis		Surface-treated gravel	do	[1] 36,529.36	[1] 10,000.30
	66	Comal		Gravel, surface treated	do	[2] 8,049.00	[2] 4,024.50
Utah	34	Utah	5.740	Concrete	May 11	221,299.66	110,649.83
	11	Iron	33.300	Gravel	do	313,965.13	156,982.56
	5	Grand	2.460	Earth	May 5	[1] 77,174.16	[1] 38,587.08
Virginia	56	Tazewell	5.505	Gravel	May 8	66,421.78	33,210.88
	74	Princess Anne	10.977	Concrete and reinforced concrete	do	408,648.92	204,324.46
	19	Fauquier		Waterbound macadam	May 18	[1] 16,557.70	[1] 8,278.85
	51	Loudoun		do	do	[1] 6,467.40	[1] 3,233.70
Washington	49	King	4.840	Concrete	Apr. 26	151,219.64	75,609.82
West Virginia	61A	Summers	1.816	Earth	May 17	38,000.00	19,000.00
	69	Braxton	6.540	do	May 28	79,875.00	39,937.50
	50A	Clay	2.950	do	do	62,600.00	31,300.00
	3A	Pendleton		do	May 11	[1] 4,234.89	[1] 2,472.10
Wisconsin	99	Douglas and Washburn		Gravel			[1] 3,039.39
	13	Park		Earth	May 12	[1] 26,572.58	[1] 8,623.79
	76	Portage	6.400	Gravel	do	[3] 32,292.92	[3] 10,764.30

[1] Modified agreements. Amounts given are increases over those in the original agreement.
[2] Modified agreements. Increase. Revised statement.
[3] Canceled.
[4] Modified agreements. Amounts given are reductions from those in the original agreement.

ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free.

REPORTS.

*Report of the Director of the Office of Public Roads for 1916. 5c.
*Report of the Director of the Office of Public Roads for 1917. 5c.
Report of the Director of the Bureau of Public Roads for 1918.
Report of the Chief of the Bureau of Public Roads for 1919.

DEPARTMENT BULLETINS.

Dept. Bul. 105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
136. Highway Bonds.
220. Road Models.
230. Oil Mixed Portland Cement Concrete.
249. Portland Cement Concrete Pavements for Country Roads.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
314. Methods for the Examination of Bituminous Road Materials.
347. Methods for the Determination of the Physical Properties of Road-Building Rock.
*348. Relation of Mineral Composition and Rock Structure to the Physical Properties of Road Materials. 10c.
370. The Results of Physical Tests of Road-Building Rock.
373. Brick Roads.
386. Public Road Mileage and Revenues in the Middle Atlantic States, 1914.
387. Public Road Mileage and Revenues in the Southern States, 1914.
388. Public Road Mileage and Revenues in the New England States, 1914.
389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
390. Public Road Mileage in the United States, 1914. A Summary.
393. Economic Surveys of County Highway Improvement.
407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
414. Convict Labor for Road Work.
463. Earth, Sand-Clay, and Gravel Roads.
532. The Expansion and Contraction of Concrete and Concrete Roads.
537. The Results of Physical Tests of Road-Building Rock in 1916, Including all Compression Tests.
555. Standard Forms for Specifications, Tests, Reports, and Methods of Sampling for Road Materials.
583. Reports on Experimental Convict Road Camp, Fulton County, Ga.
586. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1916.
660. Highway Cost Keeping.
670. The Results of Physical Tests of Road-Building Rock in 1916 and 1917.
691. Typical Specifications for Bituminous Road Materials.
704. Typical Specifications for Nonbituminous Road Materials.
724. Drainage Methods and Foundations for County Roads.
Public Roads, Vol. I, No. 11. Tests of Road-Building Rock in 1918.

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* Department supply exhausted.

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